HAZARD ANALYSIS

FOR THE

STATE OF WISCONSIN

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Department of Military Affairs
Wisconsin Emergency Management
2400 Wright Street, P.O. Box 7865
Madison, Wisconsin 53707-7865
(608) 242-3232

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INTRODUCTION

Wisconsin is vulnerable to a wide range of hazards, both natural and technological. Natural hazards such as floods, tornadoes, winter storms and excessive heat have caused injuries, loss of life, disruption of essential services, significant property damage and crop damage. Advancements in technology have resulted in a range of radiological, biological and chemical hazards, many unknown 20 or 30 years ago. Religious and political extremists have attacked government, military and civilian targets both in the United States and abroad. Managing these diverse threats and protecting lives and property is the challenge faced by emergency management officials at all levels of government. Effective emergency management must attain the capability to plan and prepare for, respond to, recover from and mitigate all types of hazards. To do this an awareness and understanding of the probability and impact of disasters resulting from these hazards must be developed. The first step in this process is the preparation of a hazard analysis. This not only increases awareness, understanding and the ability to determine probability of occurrence within a specific area and actual vulnerability; it enables decision-makers to set goals and priorities for planning, training, preparedness activities and allocate resources on a day-to-day and disaster basis.

The scope of this document is statewide. It details the hazards that have caused or are likely to cause disasters in Wisconsin. This report also discusses hazards that threaten public health and safety, but may not be likely to cause a disaster. The descriptions of disasters, hazards and threats include information on frequency of occurrence, significant occurrences, potential and actual impacts and related programs. Wherever possible, maps, charts and supplemental materials have been included to illustrate or emphasize areas of particular vulnerability, provide historical data and impart statistical information. This report may be utilized as a reference document and resource for the preparation of county, local and municipal hazard analyses.

It is Wisconsin Emergency Management's (WEM) policy to update the State Hazard Analysis document on a biennial basis. Copies are distributed to each county emergency management director and appropriate state agencies. County emergency management directors are encouraged to use the information in this document to complete the required update of their respective county hazard analyses.

WEM would like to acknowledge the assistance and contributions of information from federal, state and local agencies in the preparation of this document. Of special merit are the contributions from the National Weather Service; the Federal Emergency Management Agency (FEMA); the Wisconsin Departments of Natural Resources, Transportation, Corrections and Agriculture, Trade and Consumer Protection; the State Climatologist; and the Wisconsin Agricultural Statistics Service.

AIR TRANSPORTATION INCIDENTS

Hazard Description: Air transportation incidents include accidental and intentional crashes or collisions involving any type of aircraft. Serious air transportation accidents involve primarily large commercial passenger airlines.

Hazard Assessment: Air transportation incidents can result from a number of causes including human error, mechanical failure, poor weather conditions, hijacking, sabotage and deliberate use of the airplane as a weapon. The overwhelming majority of most airplane incidents are accidental in nature. The risk of an accidental airplane crash is usually greatest during landing and take-off operations. As a result, the areas adjacent to airports and in airport approach and departure paths are most vulnerable to this hazard and flight plans are usually designed to minimize risk should an accident occur. During times of heightened security due to terrorist threat, flight plans may be changed to maintain greater distance between airline flight paths and vulnerable targets. Weather is often a factor in airline accidents, particularly high winds and ice storms, and may impede rescue efforts. When an air transportation incident results in a crash, emergency response personnel may have to confront secondary effects like fires and hazardous material spills. Responder actions may need to include search and rescue efforts for survivors, establishing field medical or mortuary facilities for victims and crash site security for crowd and traffic control. Local law enforcement agencies will need to provide crash security and may initially investigate the incident if they have the capability. It must be stressed that when a commercial passenger airplane accident occurs or any type of aircraft crashes into a densely populated area, area response teams and emergency facilities must be prepared to find, rescue, transport and medically treat mass casualties. Any response operation may evolve quickly and give rise to difficulties with communicating and coordinating efforts among multiple responders. The more responders involved, the more difficult it is to keep the operation well coordinated. However, commercial airline accidents involving large capacity aircraft are rare in Wisconsin. Most Wisconsin air transportation incidents are accidents involving small privately owned airplanes or small commercial air taxis.

There are 726 aircraft landing areas in Wisconsin as of the end of calendar year 2001. The number of both private use and privately owned airports operating in Wisconsin increased slightly in 2000 and remained virtually steady in 2001, decreasing by just 1. The table below summarizes the type and number of landing facilities from 1996 to 2001.

Wisconsin Landing Facilities on Record

	1996	**1997**	**1998**	**1999**	**2000**	**2001**
Airports open to the public	133	133	132	131	136	136
Publicly owned	95	95	97	97	98	98
Privately owned	38	38	35	34	38	38
Private use airports	408	395	403	419	426	430
Heliport	108	111	115	120	131	126
Seaplane bases	28	26	26	27	27	27
Military/Police fields & helipads	7	7	7	7	7	7
Total	**684**	**673**	**683**	**704**	**727**	**726**

Source: Wisconsin Department of Transportation, Bureau of Aeronautics, 2002.
http://www.dot.state.wi.us/dtid/boa/01activity.htm

There are 11 airports in Wisconsin that provide regularly scheduled commercial flights. The table below illustrates airport operation trends for Wisconsin's airports with scheduled carrier service. Total operations for 2001 decreased by 0.83% or 8,358 operations. Only four of these airports reported increases in 2001. Total aviation operations decreased in 2001 for the second year in a row. Operations are defined as any take off or landing by any type of aircraft, including freight, charter, or helicopter whether it is commercial, private, government or military.

Wisconsin Airports with Scheduled Air Carrier Service
Total Annual Operations 1998 - 2001

Location/Airport	Tower Hours	1998	1999	2000	2001	% Change (00-01)
Milwaukee-General Mitchell International	24 hours	219,087	221,866	221,855	211,512	-4.8
Madison-Dane County Regional	6AM – 11PM	144,712	153,200	134,692	128,555	-4.8
Oshkosh - Wittman Regional	6AM – 10PM	88,809	115,500	104,393	103,399	-1.0
Waukesha - Crites Field	6AM – 9PM	89,662	96,160	90,472	96,032	6.1
Kenosha - Kenosha Regional	7AM – 9PM	78,826	87,545	89,221	99,093	11.0
Janesville - Rock County	6AM – 9PM	72,128	82,675	76,671	80,740	5.3
Milwaukee - Timmerman	7AM – 9PM	82,195	79,815	76,437	76,867	.5
Green Bay - Austin Straubel International	5:30AM – 11:30PM	67,835	74,389	65,480	63,405	-3.3
Appleton - Outagamie County Regional	5:30AM – 11PM	62,383	61,822	63,858	56,805	-12.4
LaCrosse - LaCrosse Municipal	6AM – 9PM	45,613	45,716	44,064	42,490	-3.7
Mosinee - Central Wisconsin	6AM – 10PM	37,775	38,397	38,455	38,342	0
Total		**989,025**	**1,057,085**	**1,005,598**	**997,240**	**-0.83**

Source: Wisconsin Department of Transportation, Bureau of Aeronautics, 2002.
http://www.dot.state.wi.us/dtid/boa/01activity.htm

Each public and private airport facility that services Wisconsin is listed on the following page. The graph on page 4 indicates the total number of passenger enplanements from 1992 through 2001. This graph shows that the number of airline passengers has been increasing every year except 2001.

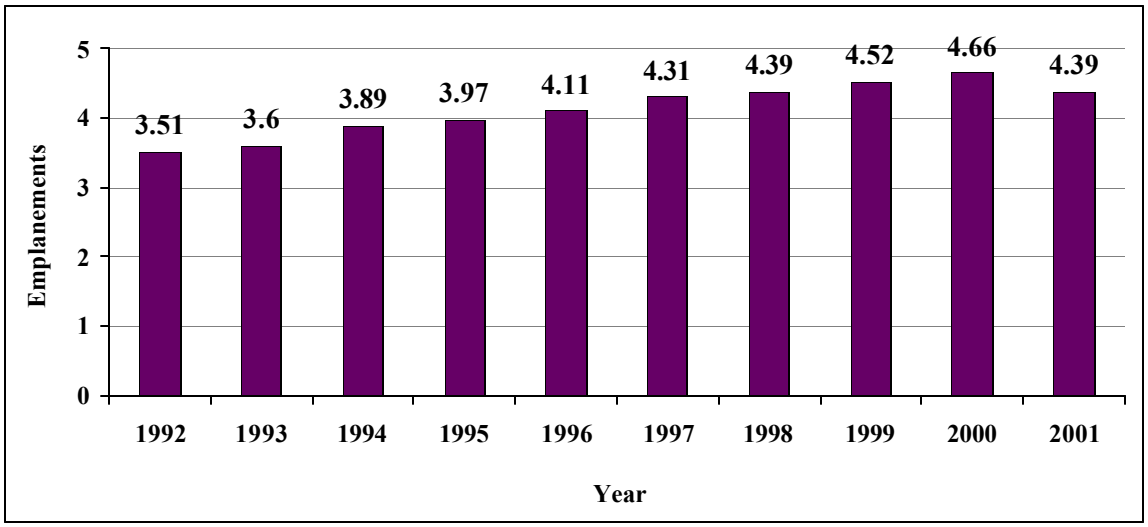
Public and Private Airports Listed by Location

Amery
Antigo
Appleton
Ashland
Baraboo-Wisconsin Dells
Barron
Beloit *
Black River Falls
Blair
Boscobel
Boulder Junction
Boyceville
Brodhead *
Brookfield *
Brule-Bayfield Co. *
Burlington
Cable
Camp Douglas
Camp Lake *
Cassville
Chetek
Clintonville
Cornell
Crandon
Crivitz
Cumberland
Delavan *
Eagle River
East Troy
Eau Claire
Edgerton *
Ephraim-Fish Creek (Sister Bay)
Fond du Lac
Fort Atkinson
Franksville
Friendship/Adams
Genoa City
Grantsburg
Green Bay-Austin Straubel
Hartford
Hayward
Hillsboro
Iola
Iron Mountain, Michigan #
Iron River-Bay Co.
Ironwood, Michigan #
Janesville
Juneau
Kenosha
La Crosse
La Pointe
Ladysmith
Lake Geneva *
Lakewood *
Lancaster
Land O'Lakes
Lone Rock
Madison-Cottage Grove*
Madison-Dane Co.
Manawa-Central Co. *
Manitowish Waters
Manitowoc
Marshfield
Medford
Menominee, Michigan #
Menomonie
Menomonie Falls
Merrill
Middleton-Morey
Milwaukee-Mitchell
Milwaukee-Timmerman
Mineral Point-Iowa Co.
Minocqua
Monroe
Mosinee
Necedah
Neenah *
Neillsville
New Holstein
New Lisbon
New Richmond
Oconto
Osceola
Oshkosh
Palmyra
Park Falls
Phillips
Platteville-Grant Co.
Portage
Prairie du Chien
Prairie du Sac
Prentice
Pulaski *
Racine *
Red Wing, Minnesota #
Reedsburg
Rhinelander
Rice Lake
Richland Center
Rio *
Rio Creek
River Falls
Rochester *
Shawano
Sheboygan Falls
Shell Lake
Shiocton *
Siren
Solon Springs
Sparta-Fort McCoy
Stevens Point
Sturgeon Bay
Sturtevant *
Superior
Suring-Piso*
Three Lakes
Tomah
Tomahawk
Verona *
Viroqua
Walworth *
Washington Island
Watertown
Waukesha
Waunakee *
Waupaca
Wausau
Wautoma
West Bend
Wild Rose
Wilmot *
Wisconsin Rapids
Wonewoc

* Denotes private airport
\# Denotes out-of state airports used by people in some areas of Wisconsin

SOURCE: Wisconsin Department of Transportation, Bureau of Aeronautics. http://www.dot.state.wi.us/dtid/boa/airportdirectory.htm, January 2001.

Wisconsin Air Carrier Enplanements (Millions)



Source: Wisconsin Department of Transportation, 2002. http://www.dot.state.wi.us/dtid/boa/01activity.htm

Programs: The Federal Aviation Administration (FAA) regulates all private and commercial aircraft in the U.S., promulgating standards and conducting compliance audits for aircraft, aircrews, maintenance personnel and airport facilities. In addition the Aviation and Transportation Security Act authorizes the federal Department of Transportation to enact airport security measures designed to prevent acts of such as sabotage, hijacking, or terrorism. The Wisconsin Department of Transportation's Bureau of Aeronautics works closely with federal, state and local governments and with aviation industry associations. The Bureau has state permit authority for airport site approval and tall structures construction. The Bureau provides safety and technical education programs to assist pilots, flight instructors and mechanics in meeting FAA regulatory requirements. Counties and municipalities with major airports routinely conduct exercises to test their response capabilities, particularly those of fire, emergency medical, mortuary and law enforcement agencies.

Significant Incidents: Since 1970 there have been two airplane hijackings originating in Wisconsin. On January 22, 1971 a single individual hijacked a Northwest flight from Milwaukee to Detroit and redirected the flight to Cuba. None of the 60 passengers on board was seriously injured. On November 23, 1978, a single hijacker unsuccessfully tried to take control of a flight from Madison to Milwaukee. The flight's passengers overpowered this individual (Source: http://aviation-safety.net/database/hijackings/index.html).

Wisconsin's worst air crash killed 31 people at Milwaukee's Mitchell Field on September 6, 1985. A Midwest Express Airline DC-9 jet aircraft went into a roll shortly after takeoff, crashed and burst into flames, killing all passengers and crewmembers. The worst previous crash occurred on June 29, 1972, when two commuter turboprop planes collided in mid-air above Lake Winnebago, killing all 13 people on board the two aircraft.

From January 1,1996 through December 31, 2001 the National Transportation Safety Board, Aviation Safety Database reported 243 air traffic accidents in Wisconsin. Of these 243 accidents, 47 resulted in at least one fatality with a total of 82 fatalities during this period. All but two of these accidents involved private aircraft. The two commercial flights that had an accident were chartered air taxi flights. None of the accidents involved regularly scheduled commercial passenger airlines. The table on the next page summarizes fatal aircraft accidents by aircraft type and location.

Fatal Air Traffic Accidents from January 1, 1996 to December 31, 2001

Date	Location	Make / Model	Fatalities	Name or Type of Carrier
1/17/96	Milwaukee, WI	Piper PA-32	1	Private
5/4/96	Lancaster, WI	Mustang M-II	1	Private
6/29/96	Racine, WI	Piper J3C-90	1	Private
8/8/96	Fond du Lac, WI	Lancair 320	1	Private
9/4/96	Tomahawk, WI	Beech 23	1	Private
3/15/97	Newton, WI	Douglas DC-3C/BT-67R	4	Private
3/15/97	Newton, WI	Beech A36	4	Private
8/2/97	Superior, WI	Briegleb BG-12A	1	Private
8/4/97	New Richmond, WI	Beech 76	2	Private
8/4/97	Poygen, WI	Peck Osprey 2	2	Private
8/5/97	Fond Du Lac, WI	Adventurer 333	1	Private
12/13/97	Sturtevant, WI	Piper PA-28-140	1	Private
4/15/98	Ashland, WI	Cessna 180J	1	Private
5/15/98	Lagrange, WI	Commander 114-B	4	Private
7/31/98	Coloma, WI	Navion A	1	Private
8/2/98	Oshkosh, WI	Hispano Aviacion A10B-37	1	Private
8/4/98	Phillips, WI	Cessna A185F	2	Private
8/28/98	Beaver Dam, WI	Piper PA-22-150	2	Private
8/31/98	Seymour Twp, WI	Cessna 310R	2	Heartland Aviation
8/31/98	Seymour Twp., WI	Cessna 185B	2	Private
9/16/98	Oakdale, WI	Beech 58	3	Private
10/9/98	Superior, WI	Bellanca 8KCAB	1	Private
11/29/98	Coleman, WI	Cessna 172F	2	Private
4/14/99	Superior, WI	Cessna 152	2	Private
5/29/99	Comstock, WI	Champion 7ECA	1	Private
7/9/99	Menominee Falls, WI	Cessna 182E	1	Private
8/14/99	Campbellsport, WI	Johannes-Robert Acrosport RJ-2	1	Private
8/27/99	Janesville, WI	Walker Breezy	1	Private
1/6/00	Dunbar, WI	Beech D-95A	1	Private
7/28/00	Sauk City, WI	Cessna 182A	4	Private
8/15/00	Watertown, WI	Piper PA-28-161	3	Private
8/18/00	Watertown, WI	Bell OH-58C	2	Private
9/1/00	Manitowish Wtrs., WI	Beech K35	2	Private
12/3/00	Milltown, WI	Beech 95 - B55	2	Private
2/10/01	Horicon, WI	Cessna 152	1	Private
2/14/01	Webb Lake, WI	Piper PA-28R-201	4	Private
4/2/01	Ashwaubenon, WI	Cessna 501	1	Private
4/17/01	Oshkosh, WI	Beech F35	1	Private
5/16/01	Green Bay, WI	Brault Glasair SH2F	1	Private
6/16/01	La Crosse, WI	Fouga CM 170	2	Private
7/17/01	Oak Creek, WI	Cessna 310R	1	Air Taxi & Commuter
7/24/01	Oshkosh, WI	Payne Giles G-202	1	Private
7/26/01	Oshkosh, WI	Schuchart Stoddard Hamilton SH3	1	Private
7/26/01	Wheeler, WI	Bell 47G-2	1	Private
8/30/01	Stevens Point, WI	Beech A23	3	Private
9/29/01	Marshfield, WI	Cessna 414	3	Private
12/12/01	Waukesha, WI	Robinson R44	1	Private
47 Air Traffic Accidents.			**82 Fatalities**	

National Transportation Safety Board, Aviation Accident Database. http://www.ntsb.gov/NTSB/Query.htm

COASTAL HAZARDS

Hazard Description: There are three major types of natural hazards affecting the state's Great Lakes shoreline along Lake Superior and Lake Michigan. These are:

- Erosion of coastal bluffs, banks, beaches and near shore lake beds;
- Flooding from upland runoff, high lake levels and storm-induced surge (temporary water level changes); and
- Damage to shoreline structures from storm waves (WCMP 1992, p. 85).

Hazard Assessment: All 15 coastal counties in Wisconsin can experience erosion, flooding and damage to shoreline structures. Coastal erosion is a naturally occurring process that can accelerate during times of high water or wave action. For example, bluff erosion is more likely to occur during major storm events due to wave action upon the shoreline. The effects of wave-induced erosion are usually greater during those periods when the level of the water is high. The freezing and thawing of lake ice also contribute to erosion.

Coastal property owners are acutely aware of hazards during periods of high water levels and especially right after a damaging storm or a bluff failure, but this awareness can fade over time if low lake levels slow the erosion rate. Lake levels were above long-term averages from 1996 to 1998. The last period of significantly higher lake levels was during 1985-86, resulting in $16 million of documented damage to public facilities alone (WCMP 1992, p. 85).

Vulnerability to Bluff Erosion in Wisconsin: Many areas of the Wisconsin Great Lakes coast are vulnerable to bluff erosion. In general, the erodible sections of the Lake Michigan shore are found between the Illinois state line to the Sturgeon Bay Canal in Door County and in the northeastern part of Brown County on Green Bay. Along the remainder of the Lake Michigan shore, bluff erosion is limited to smaller segments of bays and clay banks. On the Lake Superior shore, bluff erosion is more localized. Vulnerability is highest along the high clay bluffs running from Bark Point in Bayfield County to Wisconsin Point in Douglas County and from Iron County to the White River in Ashland County (Springman and Born 1979, pp. 6-11).

Vulnerability to Coastal Flooding in Wisconsin: All 15 coastal counties in Wisconsin can experience some coastal flooding. However, coastal flooding is a serious issue along two low-lying sections of the Lake Michigan shore: southern Kenosha County and the western shore of Green Bay from the City of Green Bay to the Michigan state line (WCMP 1992, Addendum). Although the risk of coastal flooding is reduced when lake levels are low, lake levels are only one factor contributing to coastal flooding. Other factors include wind set-up and wave run-up. Wind set-up increases the level of the lake against which a steady wind is blowing and which causes a corresponding decrease in lake level on the opposite side of the lake. Wave run-up is also caused by wind but is also dependent on the shore profile. Waves will form more readily where there is a shallow beach profile. In these areas strong winds can cause or exacerbate coastal flooding.

Variable Lake Levels: Water levels in the Great Lakes fluctuate on both a seasonal and long-term basis. On a seasonal basis, the lakes are at their lowest levels during the winter when much of the precipitation is held on land as snow and ice. The highest seasonal levels are during the

summer when snowmelt from the spring thaw and summer rains contribute to the water supply. Long-term variation of lake levels depends on precipitation and evaporation trends in the Great Lakes watershed. Lake levels rise when net water supply exceeds outflow and above average lake levels can persist for extended periods even after the conditions that caused them have ended. The water volume of the Great Lakes is large and outflow from natural outlets is limited. Flow regulation structures exist in Lakes Ontario, Michigan and Superior, but their influence is limited by their size. Controlled releases strive to simulate long-term averages in order to serve multiple interests. The source of about 40 percent of Lake Superior's annual water supply is from the snow pack around its shores. Lakes Michigan and Huron get up to 30 percent of their yearly supply from Superior's snowmelt when it flows into the lower lakes (Detroit Free Press, March 18, 2000).

Record snowfall in northern Wisconsin in 1996 was followed by near record high water levels in 1997. However, unusually mild weather and light snowfall in the winters of 1998-1999 and 1999-2000 has brought lake levels to below long-term averages. According to the Army Corps of Engineers Monthly Bulletin of Lake Levels for the Great Lakes, lake levels in Lake Superior are nearly a foot below normal and more than a foot below normal in Lake Michigan. Water levels on Lake Superior and Lake Michigan recovered somewhat in 2001 but remained below normal. Heavy above average rainfall in April 2002 (133% of average) has helped improve low lake levels by as much as 8 inches in the summer of 2002. The Army Corps of Engineers has begun a comprehensive study of damages caused by fluctuating lake levels in Lake Michigan. Documents describing the progress and findings of this study may be found on the Internet at http://huron.lre.usace.army.mil/coastal/LMPDS/documents.htm.

Economic Impacts of Low Lake Levels

The water level of the Great Lakes significantly affects the revenues of the shipping industry. Commercial carriers receive less revenue when water levels are low. This is because shipping is dependent on the amount of draft available in shipping channels. When the draft is reduced, the amount of revenue-generating cargo must be reduced. A 1,000-foot long vessel forfeits 270 tons of cargo for each one-inch reduction in draft. The drop in lake levels in 1999 resulted in a one-foot reduction in available draft. The loss of one foot of water means a typical 1,000-foot iron ore carrier would lose 3,240 tons of cargo. The ship would have to make 2.5 extra trips to make up the difference over the season, costing the shipping company an estimated $121,000 per ship per season (Lake Carrier's Association/Army Corps of Engineers, 1999). Economic losses also arise from restricted marina and launch traffic for charter boats, pleasure boats, commercial fishing and sport fishing when lake levels are low. Although dredging can improve access to the lakes, it is often damaging to the aquatic environment and many cases not cost effective.

Population Trends in Coastal Counties

According to the 2000 Census, a total of 1,992,393 people, 37.1 percent of the population of Wisconsin lives in Wisconsin's 15 coastal counties, 84,612 more people than in 1990. The 1990-2000 population growth rate of Wisconsin's coastal counties was 4.4 percent compared to 13 percent for inland counties. This difference is largely attributable to the drop in population in Milwaukee County. If Milwaukee County is not included in the summary statistics, the population of coastal counties in Wisconsin has grown at an average of 10.9 % from 1990 to 2000. It is notable that Brown, Iron, Kenosha, and Oconto Counties all experienced double digit population growth in

excess of the state average. Population growth is a good indicator of development pressure in coastal zones.

Population Trends in Wisconsin's Coastal Counties

COASTAL COUNTY	1990 CENSUS	2000 CENSUS	1990-2000 DIFFERENCE	1990-2000 % CHANGE
ASHLAND	16,307	16,866	559	3.4
BAYFIELD	14,008	15,013	1,005	7.2
BROWN	194,594	226,778	32,184	16.5
DOOR	25,690	27,961	2,271	8.8
DOUGLAS	41,758	43,287	1,529	3.7
IRON	6,153	6,861	708	11.5
KENOSHA	128,181	149,577	21,396	16.7
KEWAUNEE	18,878	20,187	1,309	6.9
MANITOWOC	80,421	82,887	2,466	3.1
MARINETTE	40,548	43,384	2,836	7
MILWAUKEE	959,275	940,164	-19,111	-2
OCONTO	30,226	35,634	5,408	17.9
OZAUKEE	72,831	82,317	9,486	13
RACINE	175,034	188,831	13,797	7.9
SHEBOYGAN	103,877	112,646	8,769	8.4
COASTAL TOTAL	**1,907,781**	**1,992,393**	**84,612**	**4.4**

Wisconsin Coastal and Inland Population Trends Compared

COUNTY AREA	1990 POPULATION	1990 PERCENT	2000 POPULATION	2000 PERCENT	1990-2000 DIFFERENCE	1990-2000 PERCENT	1990-2000 PERCENT CHANGE
Coastal	1,907,781	39.0%	1,992,393	37.1%	84,612	17.9%	4.4%
Inland	2,983,988	61.0%	3,371,282	62.9%	387,294	82.1%	13.0%
Total	4,891,769	100.0%	5,363,675	100.0%	471,906	100.0%	9.6%

Coastal Barrier Resources

Coastal barriers are landscape features that shield the mainland from the full force of wind, wave, and tidal energies. They can take on a variety of forms including islands, spits, or mangrove trees. Established in 1982, the Coastal Barrier Resources Act (CBRA) is a federal law that eliminates federal subsidies for development on fragile, high-risk coastal barriers that have been identified by congressional committee under the advice of the US Fish and Wildlife Service. The System currently includes 585 units, about 1,200 shoreline miles. There are also 274 "Otherwise Protected Areas", a category added by the 1990 Act for coastal barriers within lands reserved for conservation purposes.

CBRA does not regulate how landowners can develop their land; rather, it transfers the full cost of at-risk development from federal taxpayers to individuals. Federal subsidies and other programs, especially the National Flood Insurance program, which are central to the economic viability of high-risk coastal areas, cannot be accessed for development within an area designated by CBRA as a coastal barrier resource unit. CBRA seeks to conserve coastal habitat, minimize potential for loss

of human life from storm surge, and reduce "wasteful" federal spending to develop – and rebuild again and again – places where storms and chronic erosion are common. Federal monies can be spent within the System for certain exempted activities, after consultation with the U.S. Fish and Wildlife Service. Examples of such activities include emergency assistance, military activities for national defense, and maintenance of existing federal navigational channels. However, since structures within a CBRA unit are not allowed to participate in the NFIP, federal money for flood hazard mitigation projects is not available.

CBRA is a map-driven law. The maps, which are approved by Congress and the Administration, cover over 1.3 million acres of privately owned, undeveloped coastal barriers along the Atlantic, Gulf, Great Lakes, and Caribbean coasts. The Act was amended in 1990, designating an additional 1.8 million acres of "otherwise protected areas," or coastal barriers protected for conservation purposes by government or non-government groups. To protect these, federal flood insurance is prohibited in "otherwise protected areas." The US Fish and Wildlife Service (the Service) administers the Act and is responsible for a number of related activities, including:

- Maintaining the official system and "otherwise protected area" maps;
- Modifying System maps every five years to reflect changes from natural processes;
- Consulting with federal agencies that propose spending funds in the system;
- Ensuring the Flood Insurance Rate Maps developed by the National Flood Insurance program accurately depict CBRA boundaries; and
- Working with private partners, state and local governments to accurately depict CBRA boundaries on local mapping systems.

All of Wisconsin's CBRA units were added in 1990 when the Act was amended. The following table describes the CBRA units in Wisconsin by county and FIRM map panel number.

Coastal Barrier Resource Systems In Wisconsin

Community	CID	FIPS Code	County	FIRM Panel Number	Map Suffix	FIRM Date	CBRS Units on FIRM Panel	Earliest CBRS Date on Map
Bayfield County (Uninc. Areas)	550539	55007	Bayfield	3	C	11/4/1992	WI-06, WI-07	11/16/1990
Bayfield County (Uninc. Areas)	550539	55007	Bayfield	4	C	11/4/1992	WI-05	11/16/1990
Bayfield County (Uninc. Areas)	550539	55007	Bayfield	8	C	11/4/1992	WI-07	11/16/1990
Brown County (Uninc. Areas)	550020	55009	Brown	100	C	11/4/1992	WI-02	11/16/1990
Manitowoc Co. (Uninc. Areas)	550236	55071	Manitowoc	10	B	11/4/1992	WI-01	11/16/1990
Marinette Co. (Uninc. Areas)	550259	55075	Marinette	950	C	11/4/1992	WI-03, WI-04	11/16/1990

Source: FEMA

Over the last two years, the US Fish and Wildlife Service has worked closely with partners to create precise, digital maps for a few CBRA areas that can be easily integrated into local tax appraiser databases and GIS planning systems. These maps increase government efficiency and allow customers to quickly find information on their properties. Using competitive sourcing of funds to government and industry experts, the Service is merging electronic government principles with the five-year review of the system.

Congress has adopted a number of these high-quality products and directed the Service to continue on this course. The Coastal Barrier Resources Reauthorization Act of 2000 directs the Service to complete a pilot study on digitizing all CBRA areas. Due in two years, the pilot study will digitally map between 50 and 75 areas affected by the law, determine the availability of digital data in all related states, and estimate the total cost of modernizing all CBRA maps.
(Sources : http://budget.fws.gov/FY%202003%20GB/03.34%20coastal.pdf and http://www.fws.gov/cep/cbrfact.html)

Programs: The Wisconsin Department of Natural Resources' Shoreland Program is a partnership between state and local government that requires the adoption of county shoreland zoning ordinances to regulate development near navigable lakes and streams, in compliance with statewide minimum standards. These minimum statewide standards, found in Chapter NR115, Wisconsin Administrative Code, seek to create a balance between private rights and public responsibilities of landowners. In brief, the four major aspects of NR115 aim to:

1) Control the density of development;
2) Create a protective buffer of vegetation along public waterways;
3) Minimize disturbances to water resources; and
4) Protect wetlands which are located near lakes and streams by prohibiting most filling or draining and by placing limits on what can be done in those special areas.

The Wisconsin Coastal Management Program oversees management of the state's coastal resources and strives to maintain a balance between preservation and economic needs. Established in 1978 under the Federal Coastal Zone Management Act, the Wisconsin Coastal Management Program works to preserve, protect and wisely use the resources of the Lake Michigan and Lake Superior coastlines for this and future generations. The Wisconsin Coastal Management Program (WCMP) provides grants to encourage the management and protection of Wisconsin's coastal resources and to increase public access to the Great Lakes. For the year 2000, the four types of matching grants available were focused on wetland protection, reducing cumulative and secondary impacts to coastal resources and coastal resource protection through land use and management planning.

A long-term project to assess the economic impact of the water levels in the Great Lakes is being coordinated by the Army Corps of Engineers, Detroit District. In cooperation with the University of Wisconsin, the Wisconsin Department of Natural Resources, several private consultants and agencies from the State of Michigan, the Corps has organized the Lake Michigan Potential Damages Study (LMPDS). The objective of this research project is “to create a modeling procedure and engineering-management tool for estimating economic effects of lake level changes and related social, environmental and cultural impacts. The LMPDS modeling approaches are expected to be the framework for economic assessments for each of the other

Great Lakes. The LMPDS is also intended to be a forum for concerted information system development between international, federal, state, county, township and municipal governance about the resource base that is commonly shared (The LMPDS Internet web site has detailed information about the study – http://huron.lre.usace.army.mil/coastal/LMPDS/documents.htm)."

Several state and local benefits should result from the LMPDS project, including better tools to predict lakeshore erosion and greater availability of erosion data. However, nature has the greatest role in determining lake levels while the Corps' ability to affect water levels on the Great Lakes through the use of water controls such as locks and dams is very limited. The key to reducing economic and environmental losses from variable lake levels must involve improving local land use planning to minimize erosion risks to lakeshore development. Development patterns and coastal geography largely determine local vulnerability to coastal storms and bluff erosion. County and municipal zoning officials and emergency management officials should be aware of local coastal conditions and take steps to protect public safety.

Additional Resources for Local Coastal Hazard Analysis:
The Wisconsin Coastal GIS Applications Project is a joint effort of the University of Wisconsin Sea Grant Institute and Land Information and Computer Graphics Facility. The Project makes coastal geography information and analysis available to coastal communities and researchers both on-line and through the University of Wisconsin at http://coastal.lic.wisc.edu/. The information available on this site includes coastal maps of Wisconsin and a document entitled, "A Resource Guide for Great Lakes Coastal Hazards in Wisconsin." Likewise, the University of Wisconsin Sea Grant web site is a useful source of information about coastal issues in Wisconsin. Access Sea Grant at http://www.seagrant.wisc.edu/index.asp.

DAM FAILURES

Hazard Description: A dam failure involves the uncontrolled release of stored water due to the breaching of a water control structure, resulting in rapid downstream flooding. A dam can fail because of excessive rainfall or melted snow, poor construction or maintenance, flood damage, earthquake activity, weakening caused by burrowing animals or vegetation, surface erosion, vandalism or a combination of these factors. Dam failures can result in the loss of life and significant property damage in an extensive area downstream of the dam.

Hazard Assessment: There are approximately 3,700 dams in Wisconsin, many of which were constructed before 1900. Some dams originally used for logging or milling operations are no longer used for their original purpose. An additional 700 dams were built but have subsequently washed out and no longer exist. Approximately 100 dams have been removed since 1967. Dams serve many purposes, including agricultural uses, providing recreation areas, electrical power generation, erosion control, water level control and flood control. The federal government has jurisdiction over large dams that produce hydroelectricity – approximately 5% of the dams in Wisconsin. Private individuals own approximately 50% of the dams in Wisconsin. The State of Wisconsin owns 19%, municipalities such as townships or county governments own 16%, and 15% are owned by various other groups. A dam with a structural height of over 6 feet and impounding 50 acre-feet or more, or having a structural height of 25 feet or more and impounding more than 15 acre-feet is classified as a large dam. There are approximately 1,200 large dams in the State of Wisconsin. The Wisconsin Department of Natural Resources regulates all dams on waterways to some degree. However, the majority of dams overall in Wisconsin are small and are not stringently regulated for safety purposes.

Among these 3,700 dams there is a wide variance in the potential to cause damage in the event of failure. Very few dams in Wisconsin were built primarily to protect people and property from floods. Most of the dams that provide a flood control benefit are large hydroelectric dams on major rivers where flood control is a secondary benefit or they are PL 566 dams built through the Watershed Protection and Flood Prevention Act of 1954. There are about 83 PL 566 dams in Wisconsin located mainly in the western part of the state. This type of dam often holds little or no water in their reservoirs under normal conditions. Since these dams only hold significant amounts of water during floods, they present a special hazard as everyday water related problems such as seepage cannot be readily seen and corrected. When floodwater does arrive, the dam is used to its maximum capacity. For this reason, flood control structures should be monitored continuously during flood events, have a trained operator, be inspected annually as well as after every flood and have regularly performed maintenance.

For emergency planning purposes, dam failures are categorized as either *rainy day* or *sunny day failures*. *Rainy day failures* involve periods of excessive precipitation leading to an unusually high runoff. This high runoff increases the reservoir of the dam and if not controlled, the overtopping of the dam or excessive water pressure can lead to dam failure. Normal storm events can also lead to rainy day failures if water outlets are plugged with debris or otherwise made inoperable. *Sunny day failures* occur due to poor dam maintenance, damage/obstruction of outlet systems or vandalism. This type is the worst case of failure and can be catastrophic because the breach is unexpected and there may not be sufficient time to properly warn downstream residents.

The Wisconsin Department of Natural Resources (DNR) assigns hazard ratings to large dams within the state. When assigning hazard ratings, two factors are considered: existing land use and land use controls (zoning) downstream of the dam. Dams are classified in three categories that identify the potential hazard to life and property downstream should the dam fail. A ***high hazard*** indicates that a failure would most probably result in the loss of life. A ***significant hazard*** indicates a failure could result in appreciable property damage. A ***low hazard*** exists where failure would result in only

minimal property damage and loss of life is unlikely. All dams perceived as posing a threat to downstream development should have a dam failure analysis performed in order to identify the hydraulic shadow (that area of land downstream from a dam that would be inundated by water upon failure of the dam during a regional flood). This information can be used to develop an Emergency Action Plan (EAP) for the dam. This EAP includes provisions for notifying emergency authorities for assistance and warning affected downstream residents if the potential for failure exists. The EAPs that exist are kept on file at the State Emergency Operations Center (Wisconsin Emergency Management, Department of Military Affairs) and in the local city or county emergency management office. Of the 966 dams Wisconsin regulates, 33 High Hazard dams and 10 Significant Hazards dams have EAPs. According to DNR's on-line database of dams in Wisconsin, there are 262 dams with a high hazard potential, 252 dams with a significant hazard potential, and 1,386 dams with a low hazard potential.

Historical Frequency: Most recently, the Radigan Dam in Douglas County sustained serious damage from the flooding associated with Disaster 1369 during May 2001. The amount of damage exceeded $300,000; much more than the Town of Dairyland, owner of the dam, could afford. Fortunately, the dam did not completely fail. Between 1990 and 1995, over 75 dam failures were documented in the state. Many of these dam failures were associated with the Great Midwest Flood of 1993. Fortunately, none of these failures resulted in loss of life. During several of these incidents, however, injuries and extensive property damage did occur.

In September 1994, heavy rainfall in Price County caused concern over the potential failure of the Musser, Jobe and Weimer Dams. The Musser Dam was the most seriously threatened and the county emergency management office set up a command post above the dam to monitor it and coordinate the sandbagging efforts of local crews augmented by the Wisconsin Conservation Corps. Wisconsin Emergency Management and Department of Natural Resources Dam Safety personnel were dispatched to the command post. An evacuation of low-lying areas below the dam was ordered as construction crews attempted to open the inoperable floodgates. Their efforts were successful and this allowed maximum release of water behind the dam, averting a near catastrophic situation. The Ladysmith Dam in Rusk County did overtop during this event and fail at the left abutment. City, County and State emergency personnel responded.

In March 1993, the Briggsville Dam in Marquette County failed and washed out the embankment. Fortunately, severe property damage was averted, but a recreational lake was totally drained. This failure was just one of many which occurred in 1993, a record year for precipitation and flooding. One of the more publicized incidents was that involving the Hatfield Dam in Jackson County. Due to the flooding a power canal dike at the dam failed. Initial reports from the area indicated that the main dam had failed, but this proved to be incorrect. A summary of dam washouts, overtopping or damages that were associated with the 1993 precipitation and flooding follows on page 16.

In June 1990 heavy rains stressed the Hillsboro Dam in Vernon County and it threatened to breach. The Village of Union Center was evacuated and other villages below the dam were alerted to prepare for evacuation. Quick response by emergency workers prevented the dam from failing and resultant loss of life and property.

Excessive precipitation (nine inches of rain in four hours) in August 1990 greatly stressed the 50-year old Lake Tomah Dam and imperiled the lives of some 2,000 residents of the City of Tomah who were evacuated from their homes. Municipal workers, volunteers and Wisconsin National Guard personnel averted a breach by using more than 20,000 sand bags to reinforce the structure. A large crane was used to open the floodgates and the level of the lake dropped eight inches in an

hour. The excess water emptied into the Lemonweir River, which overtopped its banks and rose approximately two inches per minute until it stabilized.

Heavy rainfall created a breach in the Orienta Dam in 1985, causing major damage to the powerhouse. Approximately two-thirds of all dam failures are caused by floods. Northern States Power Company Report (as reported by Wisconsin Department of Natural Resources, 1999).

On the night of September 1, 1985, a vicious flood nearly overtopped the 66-foot tall Orienta Falls electrical power-generating dam on the Iron River in Bayfield County. The events were chronicled the next morning in photographs taken by employees of Northern States Power (NSP), who circled helplessly in a helicopter, watching as the raging waters overwhelmed the earth embankment and bulldozed away the dam's powerhouse walls. It wasn't just the dam that was destroyed, according to The Evening Telegram, a local newspaper. At least three bridges came down as well, including the one at the mouth of the Iron River on Highway 13, where it joins Lake Superior. Telephone service was cut, many roads and culverts were washed away and though no one died, two families downstream were evacuated for fear the whole dam would go. The flood brought down the Orienta Dam, but changing times prevented its repair. NSP couldn't justify spending half a million dollars to rebuild a dam that generated only meager profits. The river was returned to its natural state and as a result improved trout fishing. However, some residents long for the scenic beauty of the flowage or small lake the dam had provided (Katherine Esposito, Wisconsin Natural Resources Magazine, April 1999).

Programs: Chapter 31 of the Wisconsin State Statutes regulates dam safety activities. By virtue of this statute, the Department of Natural Resources (DNR) has the authority over the operation and maintenance, construction, modification, change of ownership and flow control of dams not under federal jurisdiction in the state. About 119 dams used to produce hydroelectric power in the state are under federal regulation by the Federal Energy Regulatory Agency (FERC). FERC maintains specific flow operation requirements, regular inspections and an EAP as part of their licensing process.

About 1,100 of the 3,700 dams in Wisconsin are classified as large dams. The DNR is required to inspect all large dams at least once every ten years. Following the inspection, DNR sends a report to the dam owner outlining needed repairs and a schedule for completing the repairs. The owner is responsible for all costs of completing the repairs. The DNR has programs that can provide partial funding for costs associated with the repair or removal of municipally owned dams.

DNR Administrative Code NR 333 requires any new large dam constructed to have an EAP. This code also states that for any large dam to be considered safe it should have an EAP. Non-FERC licensed dams are not legally required to have EAPs unless they were a recipient under the DNR grant fund program or have been otherwise directed by the DNR to prepare one. EAP development is highly encouraged for all dams, whether or not they have development directly downstream.

The DNR board has revised Wisconsin Administrative Code Chapters NR 116.08 and NR 333 that govern dam design and construction standards and zoning downstream of dams. The revised code was effective August 1, 2001 and makes the following changes:

- Revises standards for dam design and construction by adding definitions for development, land use controls and open space use. The proposed rule eliminates the unnecessary term "preliminary dam hazard rating" in favor of "dam hazard rating" and allows for the assignment of a dam hazard rating for existing dams after a directive in a dam safety inspection report is issued and clarifies that the necessary dam failure analysis is to be provided by the owner.
- Provides more detail on the minimum contents of the required engineering consultant's report on the hydraulic, hydrologic and stability analyses and eliminates suggested dam breach parameters since they are in the DAMBRK and FLDWAV computer model user documentation.
- Greatly simplifies language on dam hazard rating determinations and adds language that considers the potential or probable loss of human life in the hazard rating definitions.
- Eliminates the unnecessary distinction between minor and major dams.
- Specifies minimum standards for an adequate emergency action plan in the event of a dam failure.
- Extends required time limits for Department approvals or actions.
- Eliminates the existing paradox that a dam owner could face by trying to comply with NR 333 requirements to secure a low hazard rating for the dam and the associated less costly lower spillway capacity requirements. Once the dam has met the low hazard requirements of NR 333 it can be considered a "safe" dam under the current NR 116.08 standards. This would then allow a community to adopt floodplain zoning downstream of a "safe" dam that could allow development to occur below the dam. This new development would then change the dam hazard rating to significant or high and would require the dam owner to undertake significant and potentially costly modifications to increase the dam's spillway capacity to the higher requirements of NR 333 for significant or high hazard dams. Without this concurrent revision to NR 116 it could be very difficult to convince a dam owner of the advantages, cost savings, reduced liability and greater protection of life, health, and property gained by securing a low hazard rating for the dam.

Resources: The Wisconsin Department of Natural Resources has an Internet-based map application for viewing and searching for information about significant dams in Wisconsin. This mapping application can be accessed at http://gomapout.dnr.state.wi.us/website/wwi/dams/viewer.htm. The database has about 1,900 dams on record. For more information about DNR's dam safety program, contact Meg Galloway, (608) 266-7014 or John Coke, (608) 266-7037.

Summary of Dam Failures/Damages Associated with the 1993 Floods

During winter, the following dam washed out:

Partridge Lake Dam, Juneau County

In spring, the following dams washed out or were damaged by high water:

Wright Dam, Iowa County
Lake Emily Dam, Dodge County
Gooseville Dam, Sheboygan County
Cox Hollow Dam, Governor Dodge State Park, Iowa County
Briggsville Dam, Marquette County
Waterford Dam, Racine County
Lowell Dam, Dodge County

The following dams overtopped:

Upper Watertown Dam, Jefferson County
Hebron Dam, Jefferson County

Due to the flooding period in June the following dams washed out:

Rock Dam, Lake Dam, Eau Claire County - washed out embankment and road
Hatfield Dam power canal dike, Jackson County
ASP Cranberry, Jackson County - 2 dikes
Roberts Cranberry, Jackson County - 4 dikes
Cambria Dam, Columbia County
Bass Lake Dam, Waupaca County

Several other dams were damaged during this period in June:

Jordan Dam, Columbia County - emergency repairs to prevent embankment failure
Humbird Dam, Clark County - completely washed out the embankments around the cutoff walls
Fairchild Dam, Eau Claire County - dike overtopped and road washed out
Lake Eau Claire Dam, Eau Claire County - deep sluice gate broken in attempt to open
Blair Dam, Trempeleau County - Slow gate operation caused downstream road embankment to erode
Dells Dam, Augusta, Eau Claire County - damage to waterwheel
Packers Bay Dam, Marquette County - embankment overtopped
Shopier Dam, Rock County - emergency repairs were required to fill embankment breach
Reservoir/Dummy Dams , Oconto County - failure to fully operate gates caused lake to bypass through low area causing road damage
Upper Appleton, Outagamie County - high head caused grout patch to fail resulting in severe seepage through a rock rubble wall
Auld & Rohrer, Waupaca County - contractor breached embankment to prevent spillway construction from failing
Fox Lake Dam, Dodge County - embankment problems related to seepage at old tree roots

Other results of the flooding include:

Construction on dams was halted at Dairyland and Ladysmith due to high water
The necessity for increased numbers of inspections

Source: Wisconsin Department of Natural Resources, 1993.

DROUGHT

Hazard Description: A drought is an extended period of unusually dry weather, which may be accompanied by extreme heat (temperatures which are 10 or more degrees above the normal high temperature for the period). There are basically two types of drought in Wisconsin: agricultural and hydrologic. Agricultural drought is a dry period of sufficient length and intensity that markedly reduces crop yields. Hydrologic drought is a dry period of sufficient length and intensity to affect lake and stream levels and the height of the groundwater table. These two types of drought may, but do not necessarily, occur at the same time.

Hazard Assessment: Wisconsin is most vulnerable to agricultural drought. Wisconsin has about 16,400,000 acres of farmland on 78,000 farms and was ranked 10th in the country in overall farm receipts in 1998 (Wisconsin Agricultural Statistics Service). Even small droughts of limited duration can significantly reduce crop growth and yields, adversely affecting farm income. More substantial events can decimate croplands and result in total loss, hurting the local economy. Droughts also greatly increase the risk of forest fires and wildfires because of the extreme dryness. In addition, the loss of vegetation in the absence of sufficient water can result in flooding, even from average rainfall, following drought conditions.

Historical Frequency and Significant Incidents: Droughts, both agricultural and hydrologic, are relatively common in the state. Small droughts of shortened duration have occurred at an interval of about every ten years since the 1930's. Extended, widespread droughts have been infrequent in Wisconsin. The five most significant droughts, in terms of severity and duration, are: 1987-1988, 1976-1977, 1955-1959, 1948-1950 and 1929-1934.

Some believe the drought of 1987-1988 was the most severe ever experienced in Wisconsin and much of the Midwest. It was characterized not only by below normal precipitation, but also by persistent dry air and above normal temperatures. Stream flow measuring stations indicated a recurrence interval of between 75 and 100 years. Its effects were most severe in north-central and northeastern Wisconsin. The drought occurred early in the growing season and resulted in a 30-60% crop loss, with agricultural losses set at $1.3 billion. Fifty-two percent of the state's 81,000 farms were estimated to have crop losses of 50% or more, with 14% estimated having losses of 70% or more. A combination of state and federal drought assistance programs helped the state's farmers recover a portion of their losses. All Wisconsin counties were designated eligible for this drought assistance.

The effect of this drought on municipal and private water supplies was not as severe, with only a few reports of individual wells drying up. A number of municipal water utilities experienced maximum use of their water delivery systems. Many water utilities imposed some type of water-use reduction rules or restrictions, usually involving the limitation of lawn sprinkling and yard watering.

The drought of 1976-1977 was most severe in a wide band stretching from north to south across the state. Stream flow measuring stations recorded recurrence intervals from 10 to 30 years. Agricultural losses during this drought were set at $624 million. Sixty-four counties were declared federal drought areas and deemed eligible for assistance under the Disaster Relief Act. Additionally, numerous private and municipal wells went dry. Federal assistance was used to help communities drill new wells and obtain new water supplies.

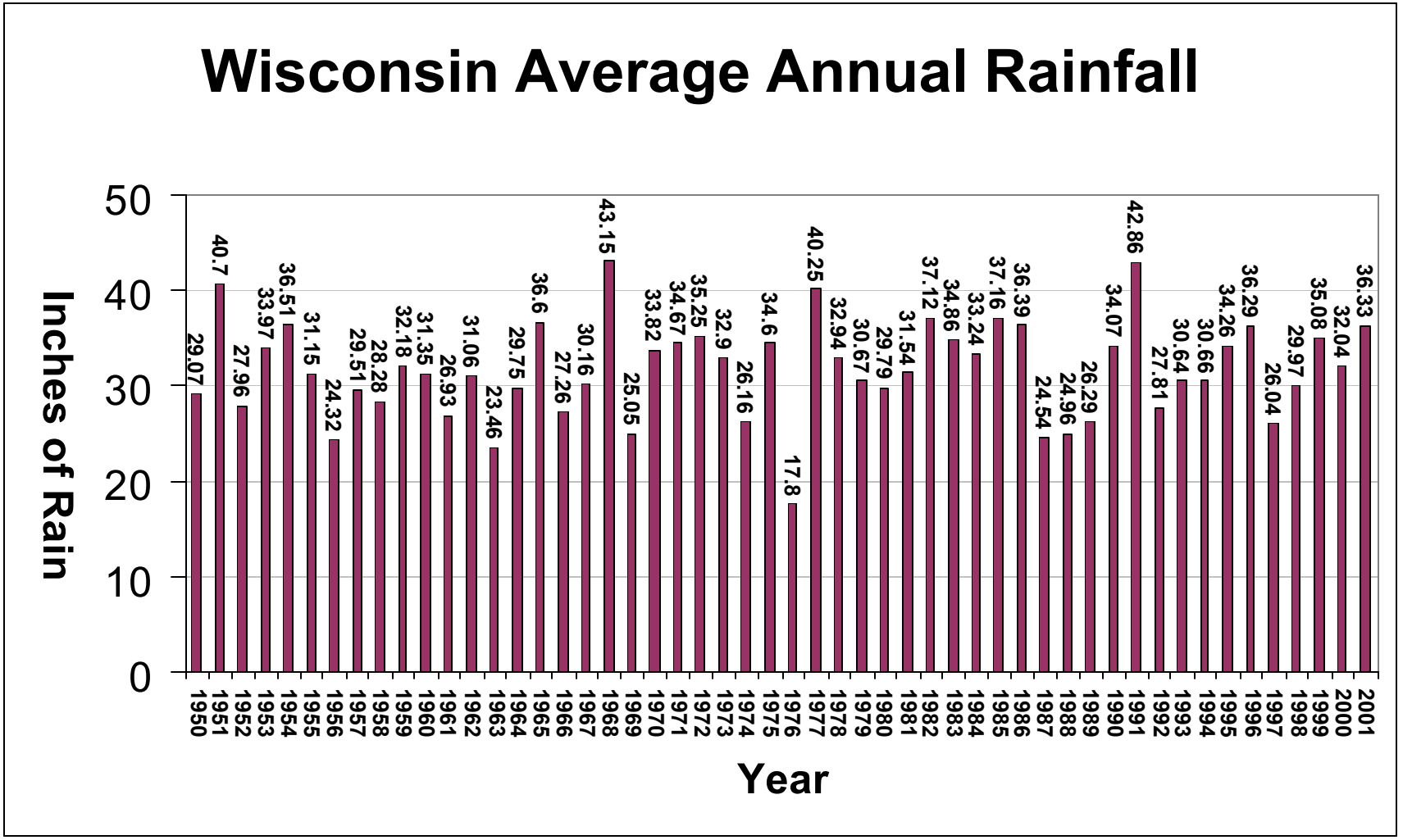
The drought of 1955-1959 had a recurrence interval of between 30 and 70 years in all but the northwestern corner of Wisconsin. The drought that occurred during 1948-1950 was most significant in the northern part of the state. In the most severely affected areas, the drought had a recurrence interval of greater than 70 years. The 1929-1934 drought probably was the most

significant in Wisconsin history, considering its duration as well as its severity. This drought had at least a 75-year recurrence interval in most of the state and over 100-year recurrence interval in certain areas. The austere economic aspects of the Depression compounded its effects. The drought continued with somewhat decreased effect until the early 1940s in some parts of the state.

Programs: When confronted with drought conditions, the state's usual course of action has been to organize an Interagency Drought Task Force, with federal, state and private sector agencies involved. The original Task Force was organized in 1976 in response to a critical drought statewide. It was reconstituted in 1988-89, once again to respond to drought conditions that prevailed throughout the state. At that time it was co-chaired by Wisconsin Emergency Management and the Wisconsin Department of Agriculture, Trade and Consumer Protection. The Task Force brought together the resources and technical expertise of the various agencies, including the University of Wisconsin Extension, to address all aspects of the drought. Examples of key activities included the operation of a Hay Hotline that matched those in need of hay or feed with potential suppliers from locations throughout the nation and the Farmers Assistance Line operated by the Department of Agriculture. The Assistance Line provided information and referrals for family farmers on a wide variety of legal, financial, employment and personal health issues.

Resources:
The University of Wisconsin Cooperative Extension has a drought disaster handbook located on the Internet at http://www.uwex.edu/ces/news/info/drought.pdf. National drought conditions can be monitored at http://enso.unl.edu/ndmc/dm/. Monthly precipitation statistics for areas of Wisconsin (as delineated by National Weather Service Weather Forecast Offices in the Midwest) are available at http://www.crh.noaa.gov/ci_climatology.html. For Wisconsin the NWS Weather Forecast Offices are located in Milwaukee, Madison, La Crosse, Green Bay, the Twin Cities (MN) and Duluth (MN). The Wisconsin State Climatology Office (http://www.aos.wisc.edu/~sco/) is a good source for general information about the climate of Wisconsin.

The chart on the following page describes the average annual rainfall for Wisconsin from 1950 through 2001.



Source: The Wisconsin State Climatology Office.

The 50-year rainfall average is 31.68 inches per year for all of Wisconsin. Rainfall will vary by region within the state.

EARTHQUAKES

Hazard Description: An earthquake is a shaking or sometimes violent trembling of the earth that results from the sudden shifting of rock beneath the earth's crust. This sudden shifting releases energy in the form of seismic waves or wave-like movement of the earth's surface. Earthquakes can strike without warning and may range in intensity from slight tremors to great shocks. They can last from a few seconds to over five minutes and they may also occur as a series of tremors over a period of several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties may result from falling objects and debris, because the shocks shake, damage or demolish buildings and other structures. Disruption of communications, electrical power supplies and gas, sewer and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides or releases of hazardous material, compounding their disastrous effects.

Earthquakes are measured by two principal methods: seismographs and human judgment. The seismograph measures the magnitude of an earthquake and interprets the amount of energy released on the ***Richter scale***, a logarithmic scale with no upper limit. This amount is expressed in Arabic numbers and each unit of increase represents a ten-fold increase in magnitude. An earthquake measuring 6.0 on the Richter scale is ten times more powerful than a 5.0 and one hundred times more powerful than an earthquake measuring 4.0. This is a measure of the absolute size or strength of an earthquake and does not consider the effect at any specific location. The ***Modified Mercalli Intensity Scale*** is an intensity scale expressed in Roman numerals, which reports the amount of shaking and effects at a specific location based on expert judgment. The scale has twelve classes and ranges from I (not felt) to XII (total destruction). No occurrence of earthquakes in Wisconsin has been severe. The most serious recorded earthquake registered 5.1 on the Richter scale and had a maximum intensity on the Mercalli Scale of VII. Below is a comparison for scales of magnitude and intensity.

Magnitude (Richter)	Intensity (Mercalli)	Description
1.0 - 3.0	**I**	**I**. Not felt except by a very few under especially favorable conditions.
3.0 - 3.9	**II - III**	**II**. Felt only by a few persons at rest, especially on upper floors of buildings. **III**. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0 - 4.9	**IV - V**	**IV**. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. **V**. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 - 5.9	**VI - VII**	**VI**. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. **VII**. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
6.0 - 6.9	**VII - IX**	**VIII**. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments and walls. Heavy furniture overturned. **IX**. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	**X** or higher	**X**. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. **XI**. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. **XII**. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: United States Geological Survey National Earthquake Information Center.

Earthquake History of Wisconsin: Moderate shaking was reported at many places in Wisconsin from the strong earthquake centered near Charleston, South Carolina, on August 31, 1886. The intensity at Beloit, Janesville and Milwaukee was estimated to have been V on the Modified Mercalli Intensity Scale (MM). A May 26, 1909, earthquake damaged many chimneys at Aurora, Illinois, and caused MM VII effects over a considerable area from Bloomington, Illinois, to Platteville, Wisconsin. Two more moderate shocks affected the same area on January 2, 1912. The first tremor was MM VI at Aurora, Freeport, Morris and Yorkville, Illinois, and was followed by a lighter shock. People noticed the tremor as far away as Madison and Milwaukee.

An earthquake centered in eastern Missouri on April 9, 1919, affected a broad area from Wisconsin to Mississippi and from Kansas to Ohio, approximately 320,000 square kilometers. In the epicenter region between St. Louis and New Madrid, windows were broken and plaster cracked. Two shocks of short duration were reportedly felt in Madison (MM II).

Scattered felt reports in Wisconsin were noted from a major earthquake in the St. Lawrence River region near La Malbaie, Quebec, Canada, on February 28, 1925. The magnitude 7.0 (Richter scale) encompassed an area of approximately 5,000,000 square kilometers. Intensity at La Crosse and Milwaukee was estimated at MM-III. Another strong Canadian earthquake (magnitude 6.25, Richter Scale) affected a large area of the northeastern and north-central United States on November 1, 1935. The area in which the quake was felt was over 2,500,000 square kilometers and included most of eastern Wisconsin (MM I - III) and scattered points elsewhere in the state.

Two strong earthquakes near Anna, Ohio, on March 2 and 8, 1937, caused damage to buildings near the epicenter and were reported to have been felt over a six-state region. The second shock was perhaps slightly stronger and more widespread than that of March 2. Both earthquakes were felt at Milwaukee; the latter tremor was also reported felt at Madison.

On November 23, 1939, a shock in southern Illinois having maximum intensity just short of damage (MM V) caused slight disturbances over an unusually large area (390,000 square kilometers). The intensity at Janesville, Wisconsin, was I - III. People in Medford, Milwaukee and Racine felt minor vibrations from a moderate earthquake in south central Michigan on August 9, 1947. Broken windows and considerable plaster and chimney damage were observed over a 30-kilometer radius from the epicenter, located near Coldwater, Michigan. The range of the earthquake covered about 130,000 square kilometers and included portions of Illinois, Indiana and Ohio.

A short but moderately strong earthquake apparently centered just south of Milwaukee caused only minor damage on May 6, 1947. There were no reports of injuries. The 4:25 a.m. CDT tremor shook buildings and rattled windows in many communities in a 7,770 square kilometer area of southeastern Wisconsin. There were a few reports of broken windows at Kenosha (MM-V) and residents of other communities reported that dishes and glasses had fallen from shelves. Some frightened Milwaukee residents ran into the streets in the belief there had been a serious explosion. The shock encompassed a 160-kilometer wide strip from Sheboygan to the Wisconsin - Illinois border and extended from the lakeshore to Waukesha, 40 kilometers inland. This

earthquake lasted only about a half a second and could have caused some serious damage if it had continued for as long as a typical major earthquake (30 or more seconds).

The strongest earthquake in the central United States in 74 years occurred on November 9, 1968, in south central Illinois. The shock was felt over an area of approximately 1,500,000 square kilometers, including all or portions of 23 states and southern Ontario, Canada. Measured at magnitude of 5.3, maximum intensity reached VII in Illinois, Indiana, Kentucky and Missouri. MM V was reported from Jefferson and Kenosha, Wisconsin and MM I - IV, at Baraboo, La Crosse, Milwaukee, Port Washington, Portage, Prairie du Chien and Sheboygan. Press reports indicated that the shock was also felt at Beloit, Janesville and Madison.

Another earthquake in Illinois, about 500 kilometers north of the 1968 epicenter, caused slight damage at several places in Illinois, Indiana, Iowa and Wisconsin. The September 14, 1972, tremor (M = 3.7) was felt over 650,000 square kilometers, including Michigan, Minnesota, Missouri, Ohio and the four states mentioned above. Cracked plaster (MM V) was noted at Kewaskum, Milton, Nashotah and Zenda, Wisconsin. A report from Browntown, Green County, said that water pipes leaked after the shock.

Reports were received from Kansasville, Mount Hope and Trevor, Wisconsin, following a magnitude 4 earthquake on April 3, 1974, centered near the 1968 epicenter in southern Illinois. Within 1 hour or so, a number of tornadoes passed through the area affected by the earthquake. It is possible some of the reports confused the effects caused by the earthquake and those caused by the tornadoes (Abridged from Earthquake Information Bulletin, Volume 10, Number 3, May - June 1978, by Carl A. Von Hake).

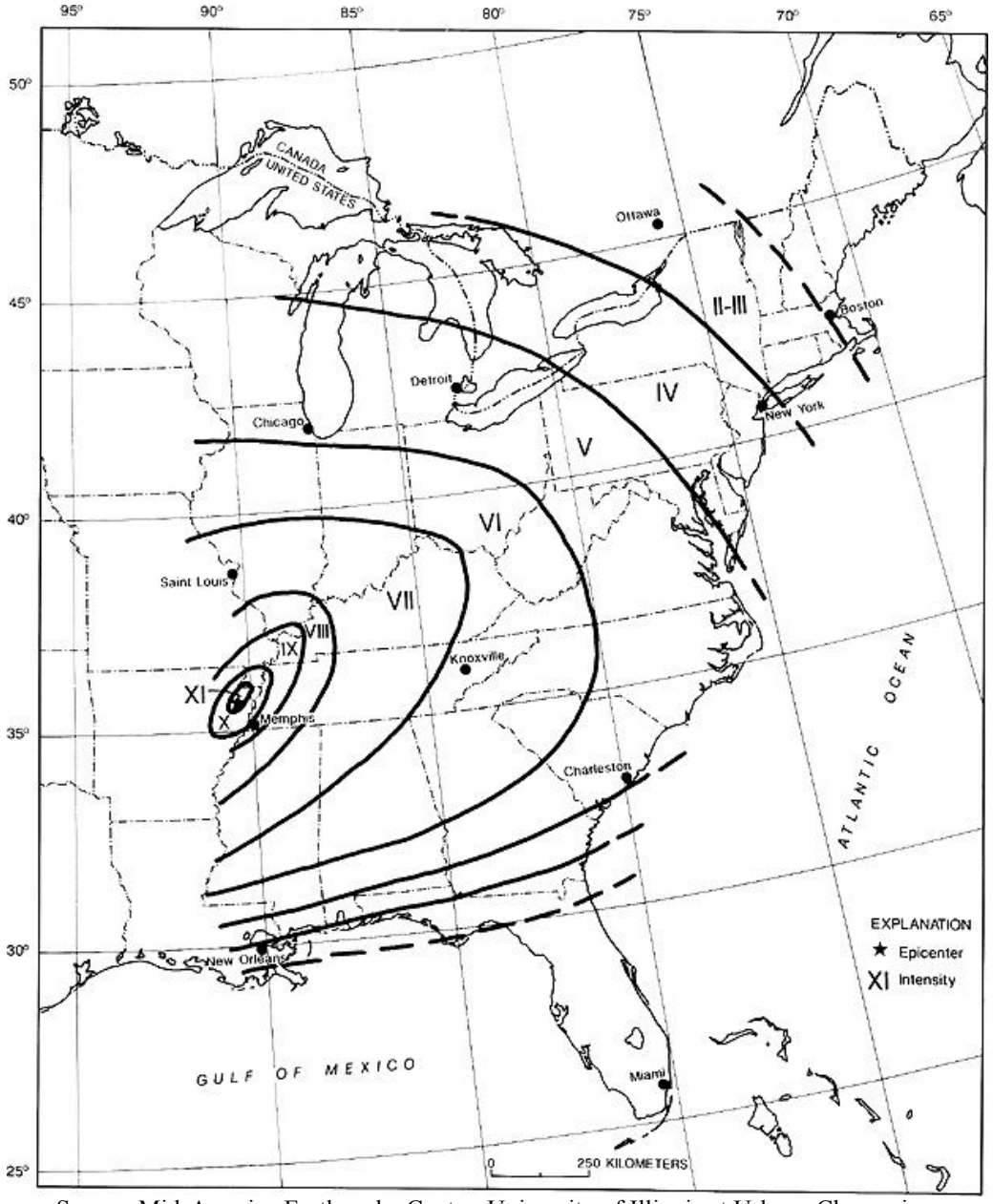
Hazard Assessment: The earthquake threat to the state is considered low. Minor damages such as plaster cracking have occurred but most often the results have been only windows rattling and ground shaking. There is little risk except to structures that are badly constructed. Most of the earthquakes that could be felt have been centered in Wisconsin and in adjacent states. The table on page 26 lists the locations and dates of the 24 recorded earthquakes that have occurred in Wisconsin since the turn of the century, with none causing significant damage. The causes of these local quakes are poorly understood and are thought to be the result of the continuing rebound of the earth's crust after the retreat of the last glacial ice.

The nearest major active fault is the New Madrid Fault, which stretches along the central Mississippi River Valley in Missouri. Considerable attention has focused in recent years on seismic activity in the New Madrid seismic zone, which lies within the central Mississippi Valley, extending from northeast Arkansas, through southeast Missouri, western Tennessee and western Kentucky to southern Illinois. Between 1811 and 1812, four catastrophic earthquakes with magnitude estimates greater than 7.0 occurred over a 3-month period. The largest earthquakes to have occurred since then were on January 4, 1843, and October 31, 1895, with magnitude estimates of 6.0 and 6.2 respectively. Instruments were installed in and around this area in 1974 to closely monitor seismic activity. Since then, more than 4000 earthquakes have been detected, most of which were too small to be felt. On average one earthquake per year will be large enough to be felt in the area.

If an 1811 size earthquake occurred, having an epicenter anywhere along the New Madrid Seismic Zone, the following counties could experience at maximum an earthquake of Mercalli Scale intensity V to VII: Milwaukee, Waukesha, Walworth, Racine, Kenosha and Rock. However, this level of intensity would not occur everywhere in these counties. Another potential impact of a major New Madrid Fault earthquake to Wisconsin could be damage to natural gas and petroleum supply pipelines that pass through or near the New Madrid Fault zone. A depiction of the regional intensity that could result from a major earthquake at the New Madrid Fault is displayed in the map below.

Regional Intensity Map

General Intensity from an 1811-Type Earthquake with an Epicenter along the New Madrid Fault



Source: Mid-America Earthquake Center, University of Illinois at Urbana-Champaign.

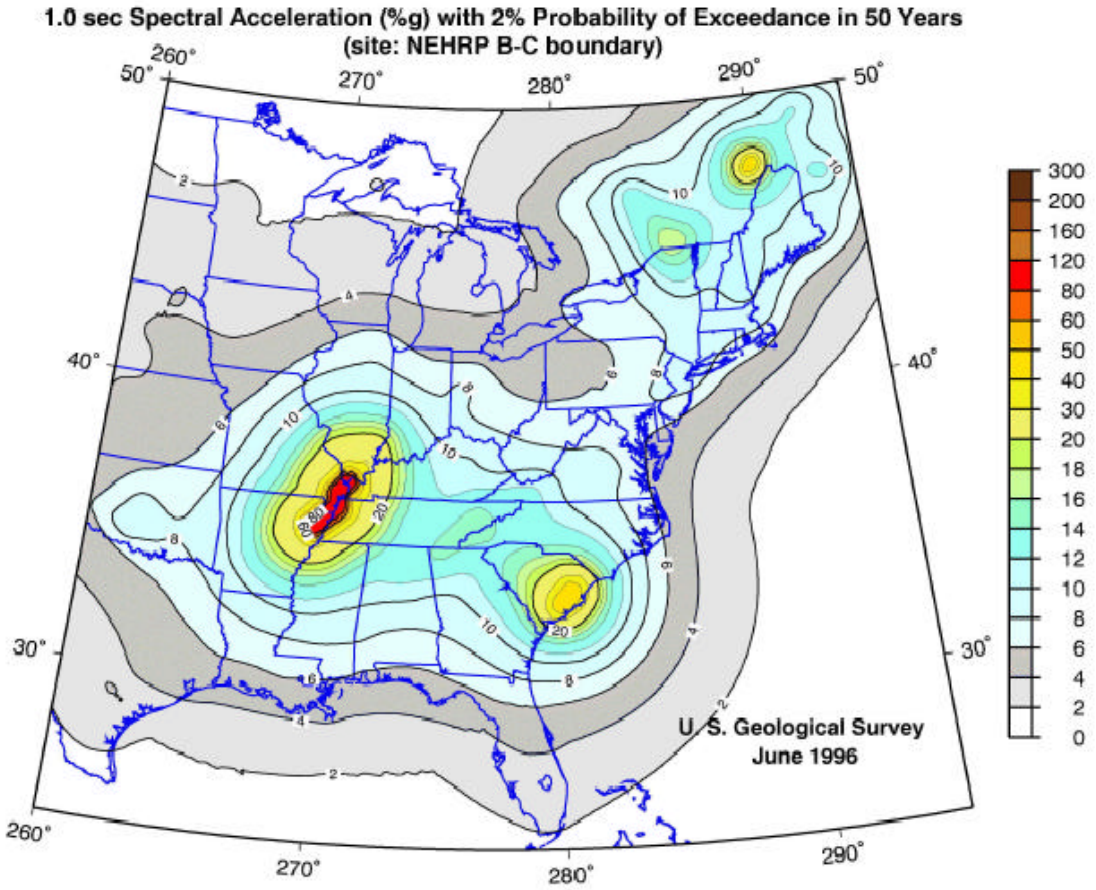
Another way of measuring the potential damage of an earthquake is the peak ground acceleration (PGA). The PGA is measured as a percentage and refers to the maximum percentage of acceleration of the movement of the ground. A higher PGA means a more rapid movement of the ground and a higher probability of structural damage. The table below provides a comparison between the Modified Mercalli Intensity scale and peak ground acceleration.

Modified Mercalli Intensity Scale and Peak Ground Acceleration Comparison

MMI	Acceleration (%g) PGA	Perceived Shaking	Potential Damage
I	< 0.17	Not Felt	None
II - III	0.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 –34	Very Strong	Moderate
VIII	34 –65	Severe	Moderate to Heavy
IX	65 – 124	Violent	Heavy
X - XII	>124	Extreme	Very Heavy

Source: USGS (Excerpted from FEMA Publication 386-2, "Understanding Your Risks." August 2001

The map below describes the peak ground acceleration from a low probability, high intensity earthquake on the New Madrid Fault. It confirms that Wisconsin has a low earthquake risk.



Source: USGS, http://geohazards.cr.usgs.gov/eq/

Historical Frequency: Earthquakes that have affected Wisconsin from 1899 to 1987 are listed on the table on page 26. The most severe earthquake that affected Wisconsin was the record earthquake of 1811, which was centered along the New Madrid Fault. Most earthquakes that do occur in Wisconsin are very low in intensity and can hardly be felt. These very minor earthquakes are fairly common, occurring every few years.

Future Probability of Major Earthquakes at the New Madrid Fault:
The New Madrid Fault system is active, averaging more than 200 earthquakes per year. Of these, eight to ten are large enough to be felt. Each year there are approximately forty-six earthquakes in the magnitude 2.0 range, and seven in the magnitude 3.0 range. Scientists at the Center for Earthquake Information have computed a set of probabilities that estimates the potential for different magnitude earthquakes to occur at the New Madrid Fault.
At this time it is not possible to predict the exact date, duration or magnitude of an earthquake. However, even an 8.3 magnitude earthquake at the New Madrid Fault would cause only minor damage in the southeastern corner of Wisconsin (Source: The University of Memphis Center for Earthquake Information http://www.ceri.memphis.edu/index.shtml).

New Madrid Fault Probabilities

Magnitude	Expected Rate (yr)
4.0	14 months
5.0	10-12 yr
6.0	70-90 yr
7.0	254-500 yr
8.0	550-1200 yr

Programs: Wisconsin is not likely to suffer direct physical damage from a severe earthquake. A more likely concern to Wisconsin is indirect effects such as the disruption in the provision of essential goods and services from the direct-impact area of a major earthquake. The Central United States Earthquake Preparedness Program Project (CUSEPP), under FEMA, is engaged in an on-going effort to reduce the hazards associated with earthquakes. Although Wisconsin is not one of the states directly involved in this program, WEM and the state indirectly benefit from its planning and actions. The program's hazard reduction efforts focus on:

- Determining the potential consequences of major earthquake events in the New Madrid seismic zone;
- Reducing or managing negative consequences through the use of zoning or building codes;
- Increasing enforcement of local mitigation codes or regulations; and
- Significantly increasing public awareness of earthquake consequences and actions that can be taken to minimize adverse effects.

Resources: Perhaps the best source of general earthquake hazard information in the United States Geological Society (USGS) at http://geohazards.cr.usgs.gov/earthquake.html. For more information about the New Madrid fault, visit the University of Memphis Center for Earthquake Information at http://www.ceri.memphis.edu/index.shtml.

Earthquake History in Wisconsin

Location	Year	Month	Day	Time C.S.T.			Latitude	Longitude	Felt Area	Maximum	Magnitude	
				H	M	S	North	West	Square km	Intensity		
1. Kenosha	1899	Oct	12	--			42° 34'	87° 50'	--	II	3.0	
2. Marinette	1905	Mar	13	22	30		45° 08'	87° 40'	--	V	3.8	
3. Shorewood	1906	Apr	22	--			43° 03'	87° 55'	--	II	3.0	
4. Milwaukee	1906	Apr	24	--			43° 03'	87° 55'	--	III	--	
5. Marinette	1907	Jan	10	--			45° 08'	87° 40'	--	III	--	
6. Beloit	1909	May	26	8	42		42° 30'	89° 00'	800,000	VII	5.1	⇐ Maximum
7. Madison	1914	Oct	07	15	0		43° 05'	89° 23'	--	IV	3.8	
8. Madison	1916	May	31	16	45		43° 05'	89° 21'	--	II	3.0	
9. Fond du Lac	1922	Jul	07	--			43° 47'	88° 29'	--	V	3.6	
10. Madison	1931	Oct	18	15	12		43° 05'	89° 23'	--	III	3.4	
11. Stoughton	1933	Dec	06	23	55		42° 54'	89° 15'	1,200	IV	3.5	
12. Dubuque	1938	Nov	07	23	30		42° 30'	90° 43'	--	II	3.0	
"	"	"	08	1	15		"	"	--	"	"	
"	"	"	"	3	30		"	"	--	"	"	
13. Thunder Mountain	1943	Feb	09	17	21		45° 11'	88° 10'	--	III	3.2	
14. Milwaukee	1947	May	06	15	27		43° 00'	87° 55'	8,000	V	4.0	
15. Lake Mendota	1948	Jan	15	11	40		43° 09'	89° 41'	--	IV	3.8	
16. Oostburg	1956	Jul	18	15	30		43° 37'	87° 45'	--	IV	3.8	
"	"	"	0	17	0		"	"	--	"	"	
17. South Milwaukee	1956	Oct	13	--			42° 55'	87° 52'	--	IV	3.8	
18. Beaver Dam	1957	Jan	08	10	0		42° 32'	98° 48'	--	IV	3.6	
19. Bill Cross Rapids	1979	Feb	28	12	4	55	45° 13'	89° 46'	Instrumental	--	<1.0 MoLg	
20. Madison	1981	Jan	09	9	15		43° 05'	87° 55'	Local	II	--	
21. Madison	1981	Mar	13	a.m.			43° 05'	87° 55'	Local	II	--	
22. Oxford	1981	Jun	12	10	30		43° 52'	89° 39'	Local	IV-V	--	
23. Milwaukee	1987	Feb	12	13	12		42° 95'	87° 84'	Local	IV-V	--	
24. Milwaukee	1987	Feb	12	13	16		43° 19'	87° 28'	Local	IV-V	--	

Source: University of Wisconsin-Extension, Geological and Natural History Survey. *List of Earthquakes in Wisconsin*, M.G. Mudrey, Jr., Open File Report 84-1, 12/11/84. Ron Friedel, Department of Geological and Geophysical Sciences, U.W. Milwaukee, 1987

FLOODS AND FLASH FLOODS

Hazard Description: Flooding occurs when a river, stream, lake or other body of water overflows its banks onto normally dry land or there is an excessive pooling of surface water. These events can be slow to develop or happen very quickly. Flash floods are usually the result of excessive precipitation or rapid snowmelt and can occur suddenly with awesome power.

Hazard Assessment: Flood related hazards in Wisconsin arise from a complex set of hydrologic and hydraulic interactions, including excessive precipitation, rapid snowmelt, ice or debris jams in waterway channels and dam or levee failures. These result in river flooding, stream flooding, coastal flooding and erosion, bank slumping, inland lake flooding, flash flooding, flooding from levee and dam failure and storm water runoff and ponding.

The effects of flooding can be devastating and cause extensive property damage. Although the probability of serious injury and loss of life is usually low, flooding increases the likelihood of long-term health hazards from water-borne diseases, mold, mildew, insect infestation and contaminated drinking water. Long-term damage to the environment may also result from flooding of sites containing hazardous materials or waste.

Major floods in Wisconsin tend to occur either in the spring when melting snow adds to runoff from rain or in summer and early fall after intense rainfalls. Flooding which occurs in the spring due to snowmelt and/or a prolonged period of heavy rain is characterized by a slow build-up of flow and velocity in rivers and streams over a period of days. This build-up continues until the river or stream overflows its banks, for as long as a week or two. The water then slowly recedes inch by inch to its original level. The expected occurrence and location of this type of flooding is fairly predictable and normally there is sufficient time for the orderly evacuation of people and property.

Flash flooding, which usually results from surface runoff after intense rains or the failure of water control structures, also poses a threat to all areas of Wisconsin. This is an extremely dangerous form of flooding because it is not very predictable. It can occur very quickly, precluding evacuation to higher ground to prevent loss of life. Small and normally calm rivers and streams will rise very rapidly when surrounding soil and terrain are unable to accommodate intense precipitation. Raging torrents of water can rip through waterways, surging well beyond normal banks and sweeping away everything in their path. Houses, structures, bridges and boulders can be tossed and rolled by a flash flood. The strength of the water current, carrying debris and surging through an area, can cause serious injuries and death. It can also interrupt power, disable fuel sources, make roads impassable, hamper response efforts and strand people in their homes awaiting rescue.

Those counties that border the Mississippi and the Wisconsin Rivers, the largest rivers in the state, are prone to flooding in low-lying areas. In addition, the Chippewa River in Eau Claire and Dunn Counties, the Kickapoo River in Crawford and Vernon Counties, the Pecatonica River and its tributaries in Green and Lafayette Counties, the Bad River in Ashland County, the Wolf River in Waupaca and Menominee Counties and the Milwaukee River have flooded periodically.

Agricultural losses from floods can be as high or higher than other forms of property damage. Agricultural losses can be in the form of crop loss, soil erosion or property damage to farm

structures and equipment. As development moves into agricultural areas flooding is likely to increase on farms and pastures near population centers due to increased stormwater run-off. For example, people have reported that agricultural areas in Waukesha County, a rapidly developing county, have flooded more often as development has increased.

Another development issue related to flooding is the demand for housing along Wisconsin's waterfronts. For example, the number of homes along all sizes of northern Wisconsin lakes has increased an average of 216 percent since the 1960s. According to the Wisconsin Department of Natural Resources, lakes that are 500 to 1,000 acres in size now have nine times as many homes as in the 1960s. In addition, some developing rural areas lack stormwater planning, flood insurance studies and flood maps.

Historical Frequency and Significant Incidents: Flooding has been a principle cause of damage in 16 out of 24 Presidential Disaster Declarations in Wisconsin from 1971 through 2001. Two costly floods occurred in 1973 and 1978 with private and public damage losses set at $24 million and $51 million respectively. The 1973 flood affected thirty-five counties. Included were counties along the Mississippi and Wisconsin Rivers, counties bordering the Great Lakes and some interior counties as well. The 1978 flood affected sixteen counties in southern and southwestern Wisconsin. The area most severely affected was that of the Kickapoo River Valley where homes were destroyed and families forced to relocate.

During the 1980s there were several significant flood events. In June and September 1980, flash flooding occurred in six northwestern and west central counties causing approximately $6 million in damage. Vernon County suffered over $1 million in flood-related losses in July 1984. Ashland, Bayfield and Douglas Counties suffered almost $3 million in public and private damages as a result of flooding that occurred during the month of September 1985. Two Presidential Disaster Declarations were received for flash flooding which occurred in August 1986 in Milwaukee and Waukesha Counties and again in September 1986 in Milwaukee, Waukesha, Ozaukee, Sheboygan, Manitowoc, Dodge, Kenosha and Washington Counties. That August, record rainfalls in the Milwaukee area and resultant flooding caused two deaths and an estimated $20 million in property damage. In September, torrential rains once again fell and associated flooding caused damage estimated at $6 million. Some of this flooding was associated with streams overtopping their banks, but overland flooding also occurred when storm and sanitary sewers were unable to handle the increased water resulting from intense precipitation.

The decade of the 1990s had eight Presidential Disaster Declarations for floods. In 1990, intense rainfall caused flash flooding severe enough to result in two Presidential Disaster Declarations. The first declaration covered late June when, on two successive weekends, record rainfalls occurred in east central and southwestern counties causing more than $20 million in losses. Federal assistance was requested and obtained for the following 17 counties: Brown, Kewaunee, Calumet, Manitowoc, Outagamie, Winnebago, Dane, Green, Rock, Grant, Iowa, Lafayette, Crawford, Richland, Sauk, Juneau and Vernon. The City of Green Bay in Brown County and the City of Darlington in Lafayette County were most severely impacted. Storm and sanitary sewer back up caused significant problems for Green Bay residents. In Darlington, the Pecatonica River once again flooded (approximately 7 feet above flood stage) and forced the evacuation of the downtown business district. On the weekend of August 17-19, 1990, the City of Tomah and surrounding areas

of Monroe County experienced a record nine inches of rain in a 24-hour period. The heavy storm runoff filled the Lake Tomah reservoir to capacity and the dam nearly failed. A portion of the city was evacuated before the dam gates were opened and a breach averted. Damage in Monroe County totaled over $3 million and a Presidential Disaster Declaration was obtained for individual assistance only.

During the period of September 14-24, 1992, severe thunderstorms with heavy rain ripped through southwestern Wisconsin, leaving in their wake extensive damage in a ten-county area. The high winds, extensive rainfall and resultant flooding caused property and agricultural losses that exceeded $17 million. A Presidential Disaster Declaration was granted on September 30, 1992, for the following ten- counties: Buffalo, Crawford, Jackson, Juneau, Pepin, Pierce, Richland, Sauk, Trempealeau and Vernon.

During the summer of 1993, the state received its worst flooding in over twenty years. Widespread rainfall and associated severe storms occurred from June 7 to August 25, 1993, resulting in a Presidential Major Disaster Declaration for 47 counties. The total associated damage exceeded $740 million. Forty of the counties were declared for both public and private assistance, with the other seven declared for Individual Assistance only. Recovery from this disaster is still continuing today. In comparison to other states in the Midwest, Wisconsin was fortunate in that our state was not as severely impacted as others; but the '93 floods are, by far, the state's worst disaster in terms not only of damages, but also in funds received through disaster relief programs. The total amount of disaster relief funds received from all declarations prior to this was $352 million. Approximately $300 million in disaster relief was received for the 1993 Presidential Disaster Declaration alone.

Heavy rains during the period of June 17-19, 1993, caused extensive flooding on the Black River. Late Sunday morning, June 20, a portion of the embankment on the power canal between Hatfield and Black River Falls failed. At approximately 2:00 p.m. the levee protecting the Grove subdivision of the City of Black River Falls began to fail due to overtopping. Approximately 90 structures were damaged in the Grove area, some having flood waters reaching the ceiling on the first floor. There were 500-700 residents estimated to have evacuated from their homes. Municipal water pumps and sewage treatment operations were shut down. Gas service to over 180 homes and businesses was also shut off. As a result streets, storm sewers, sanitary sewers, water mains, utilities and well water sources also suffered extensive damage. High water marks in Black River Falls indicated that the floodwaters reached two and a half feet above the 100-Year flood level.

Significant flooding also occurred in Darlington, Wisconsin, on the upper west branch of the Pecatonica River. Record-breaking heavy rains in early July added to previous minor flood conditions and raised levels on the Pecatonica River to a crest of 18.6 feet, 7.6 feet over floodstage. The river completely covered the Main Street bridge, effectively dividing the town. Several blocks of the downtown area had to be evacuated. The fire station was flooded, as were several businesses located downtown. An oil company with large stores of petroleum and gas in the floodplain on the northwest side and the sewage plant on the southeast side were environmental concerns because of the high water. Because of the frequent and predictable flooding that occurred in the City of Darlington, a flood warning and evacuation plan had been developed and was used. Without it, considerably more property damage and endangerment of life would have resulted. This flood event provided the incentive and the needed funding for the community to embark on a major

hazard mitigation project. Darlington was able to implement its flood mitigation and economic development plan, which entailed the floodproofing and/or acquisition and relocation of numerous downtown buildings. The project has become a model for communities interested in dealing with the effects of repetitive flooding.

Agriculture was severely impacted by the heavy rains and flooding which occurred in 1993. Thousands of acres of crops were damaged or destroyed and countless acres of rich farm soil were washed away. These losses compounded those already incurred by crop producers as a result of the lack of soil moisture in 1992 and winterkill in the first three months of 1993.

In 1996, Green County was declared for widespread flooding that took place July 17 and 18. During a 5-hour period 11 inches of rain that fell and as a result many roads were damaged and closed and seven bridges or approaches were washed-out. Basement flooding and sewer back up was prevalent throughout the county and especially in the City of Monroe and the Village of Monticello. Hundreds of homes and several businesses had flooded basements with extensive damage to furnaces, water heaters, water softeners, washers and dryers. Although Fond du Lac was also declared at the same time, the main source of damage was an F5 tornado in the Village of Oakfield, which will be discussed in more detail in the tornado section of this doucment.

On June 20 and 21, 1997, the worst rainstorm in more than a decade dumped more than 7 inches of rain in a 30-hour period in Milwaukee and the surrounding counties. The intense rainfall overwhelmed creeks and rivers as well as storm and sanitary sewers. Severe impacts from the storm were felt in Milwaukee, Ozaukee, Washington and Waukesha Counties. Hundreds of local roads and highways were filled with water, as much as 23 feet in some areas. Thousands of homes were damaged many of which had 6-7 feet of water in the basement. Hundreds more had first floor flooding with major structural damage and a dozen more houses were destroyed. The flood also damaged hundreds of businesses, many of which were forced to close temporarily or in some cases, permanently. Some of the damaged businesses that provide critical services included Bayshore Clinical Labs, St. Michael's Hospital Health Center, St. Luke's South Shore Hospital and the dialysis center in the City of Brown Deer. Damage assessments made by county emergency directors estimated disaster-related costs of $87,700,000.

From August 5 through 7, 1998, slow-moving thunderstorms dumped anywhere from five to ten inches of rain in a three to five hour period and resulted in flash flooding or urban/small stream flooding in Southeastern Wisconsin. Thousands of homes were damaged and hundreds had water above the first floor. Many sustained structural damage, with basement walls bowing or collapsing. The flooding also affected a number of businesses, some of which were temporarily or permanently forced out of operation. Tragically, two young boys lost their lives as a result of the flooding.

When all initial damage figures were compiled for the public and private sectors, they amounted to almost $55 million in losses. Most of the $44 million in private sector losses were uninsured, as flood related losses are not covered by the standard homeowner's insurance policy. The severity of the storm and significance of the uninsured losses prompted a request for a Presidential Disaster Declaration for four Wisconsin counties. The declaration was granted for both the public and private sectors. A fifth county was added later for public assistance only.

In 1999, 10 counties were declared because of damages from flash flooding and downed trees that resulted from a series of wind and rainstorms that took place from July 4 to July 30. The declared counties were Ashland, Bayfield, Douglas, Florence, Iron, Oneida, Price, Rusk, Sawyer and Vilas Counties. Many of the communities affected by the flooding and debris were small rural communities. The flash flooding washed out roads, culverts and bridges, which cut off communities from each other. Just getting the main roads passable was difficult as many of the towns had just one or two person road crews. Often roads were damaged a second or third time by the multiple storms. The floodwater also damaged homes and private wells. Many residents were isolated because they could not use roads submerged by standing water.

Flooding and flood disasters continued into the next decade. A series of severe storms from May 26 to July 19, 2000 followed the wettest month of May in southern Wisconsin since 1870. The subsequent flooding resulted in disaster declaration 1332-WI. The initial declaration occurred on June 23 and was for 12 counties in southern Wisconsin. Several storms with straight-line winds and heavy rains caused extensive damage to public infrastructure and flooded private homes. Additional storms and flood damage resulted in declarations for 10 more counties in the southern third of Wisconsin and 8 counties in the northwest part of Wisconsin. By the end of the incident period (July 19), thirty counties were included in the declaration. Thirteen counties received both Public and Individual Assistance (Columbia, Crawford, Dane, Grant, Iowa, Juneau, Kenosha, Lafayette, Milwaukee, Richland, Sauk, Vernon and Walworth). Fourteen counties received Public Assistance only (Adams, Ashland, Barron, Burnett, Forest, Green, Iron, Jackson, Monroe, Oneida, Polk, Rusk, Sawyer and Washburn). Three received Individual Assistance only (Dodge, Racine and Waukesha). The Hazard Mitigation Grant Program was made eligible statewide.

In 2001, flooding was the principle reason Wisconsin initially received Presidential Disaster Declaration, DR-1369, although tornadoes and severe storms became a major factor as the disaster progressed. Heavy winter snowfall combined with spring rain led to spring flooding. In mid-April, rain and rapid snowmelt caused the Mississippi River and many of its tributaries to flood. Floodwaters along the Mississippi River from Alma to Prairie du Chien rose to their highest levels since 1965. In addition, severe storms also struck northern Wisconsin in late April. Heavy rains mixed with freezing rain, snow and severe winds caused widespread flooding as well as wind damage. The initial flooding affected 17 counties. Eventually 32 counties were declared for DR-1369 for a variety of storm-related damage including tornadoes.

Programs: As a result of the 1993 Midwest floods, Congress authorized a special appropriation to aid flood victims and assist communities in recovering from the widespread devastation. To coordinate the distribution of these federal funds, FEMA and WEM formed an Interagency Disaster Recovery Group (IDRG), which included representatives from a variety of state and federal agencies. The group acted as a clearinghouse for communities interested in hazard mitigation or long-term recovery projects, matching proposals with grant programs and funding projects from a variety of sources. Over 100 potential hazard mitigation projects were identified.

In December 1993, as an outgrowth of the IDRG, the FEMA/WEM Hazard Mitigation Recovery Office was established for Wisconsin and located at the WEM central office. It was staffed by FEMA personnel who worked closely with the WEM State Hazard Mitigation Officer, other state agencies and local governments concerning hazard mitigation and long-term recovery issues.

Priorities in the recovery from the 1993 flooding have been the elevation of flood prone structures, the public acquisition of flooded property for open space use and the relocation of affected homes and businesses to areas outside identified flood hazard areas. The **Hazard Mitigation Grant Program** (HMGP) and HUD Community Development Block Grants (CDBG) have been used for floodproofing and elevation or acquisition of structures in flood hazard areas.

Wisconsin Emergency Management (WEM) has continued to administer the Hazard Mitigation Grant Program (HMGP) for every disaster since 1993. Since most disasters are flood related, the priorities for the HMGP continue to be reducing flood-related disaster losses. Another program available through WEM is the **Flood Mitigation Assistance Program**, which provides limited annual funds for flood mitigation planning and cost-effective flood mitigation projects. New as of 2001, the **Pre-Disaster Mitigation Program** (PDM) makes annual funds available to counties, municipalities and tribes regardless of whether or not a disaster has taken place. PDM funds may be used to produce a comprehensive all-hazards mitigation plan or for hazard mitigation projects. The Disaster Mitigation Act of 2000, which authorized the Pre-Disaster Mitigation Program, made mitigation planning a priority. Any county, municipality or tribe that wants to receive PDM project funds will need to have an approved comprehensive all-hazards mitigation plan in place. In addition, a successful applicant for HMGP funds will need to have an all-hazards mitigation plan in place or complete a plan within one year of receiving HMGP funding. More about WEM's mitigation programs may be found at http://badger.state.wi.us/agencies/dma/wem/mit_home.htm.

One of the prerequisites for access to federally funded hazard mitigation programs is participation by the county or municipality in the **National Flood Insurance Program** (NFIP). Communities that participate in the NFIP must adopt and enforce a floodplain ordinance to restrict development in the floodplain and protect against loss of life or property due to floods. In return for participation in the NFIP, people within the county or community are able to insure their homes, community buildings and businesses against flood losses. The Wisconsin Department of Natural Resources (DNR) is the state agency that coordinates the NFIP in Wisconsin. The DNR, working with local governments, is identifying special flood hazard areas in the state. Local government bodies are responsible for enacting floodplain zoning ordinances, which comply with state and federal regulations. State floodplain management regulations are found in Chapters 30.27, 59.971, 61.351, 62.231, 87.30 and 144.26, Wisconsin Statutes and Chapters NR 115, 116, 117 and 118 of the Wisconsin Administrative Code. Federal requirements for floodplain management are set forth in the National Flood Insurance Act as amended, EO 11988 and EO 11990.

NFIP Flood Insurance Statistics for Wisconsin as of 12/31/2001

Policies In-force	Coverage In-force	Premiums In-force	Total Losses	Total Payments
12,714	1,261,727,100	6,161,851	4,267	26,032,054

Source: http://www.fema.gov/nfip/datadef.htm (Note: Community level data also available here).

The DNR has also established a Municipal Flood Control Grant Program. This program offers an assistance package to cities, villages, towns and metropolitan sewerage districts concerned with municipal flood control management. Assistance is provided in two ways: (1) Local Assistance Grants that support municipal flood control administrative activities, and (2) Acquisition and Development Grants to acquire and remove floodplain structures, elevate floodplain structures, restore riparian areas, acquire land and easements for flood storage, construct flood control

structures, and fund flood mapping projects. Information and application forms are available from DNR's web site at http://www.dnr.state.wi.us/org/caer/cfa/ef/flood/grants.html.

The National Weather Service provides timely warning information concerning floods and other weather-related hazards. When severe weather conditions occur that might result in flooding or flash flooding, *flash flood watch*, *flash flood warning* or *urban and small stream flood advisory* weather bulletins are broadcast by the National Weather Service. These bulletins are disseminated over a number of telecommunication channels, including NOAA Weather Radio, the NOAA Weather Wire and the state law enforcement's TIME system. Local media routinely monitor these sources and rebroadcast the weather bulletins over public and private television and radio stations. NOAA Weather Radio is available to any individual with a weather alert radio.

Wisconsin Emergency Management, in conjunction with the National Weather Service, other state agencies and local emergency government organizations provides both flood awareness and preparedness information to the citizens of Wisconsin. Just before spring the National Weather Service provides a spring flood outlook that predicts the likelihood of spring flooding in Wisconsin rivers. In the May-June timeframe, the Wisconsin Emergency Management has a Flood and Flash Flood Awareness campaign to highlight the dangers of floods and flash floods and increase public awareness of these hazards. This information is provided annually.

Current information about flood potential by river is available on the National Weather Service's Advanced Hydrologic Prediction Services web site at http://www.crh.noaa.gov/ahps/index.html. For general climatology and local weather information such as local flood warnings and flood watches, the National Weather Service's Forecast Offices for Wisconsin are excellent sources. The NWS Forecast Offices serving Wisconsin are:

Duluth, MN http://www.crh.noaa.gov/dlh/cwa.htm
Serving Douglas, Bayfield, Ashland, Bayfield, Iron, Burnett, Washburn, Sawyer and Price Counties.

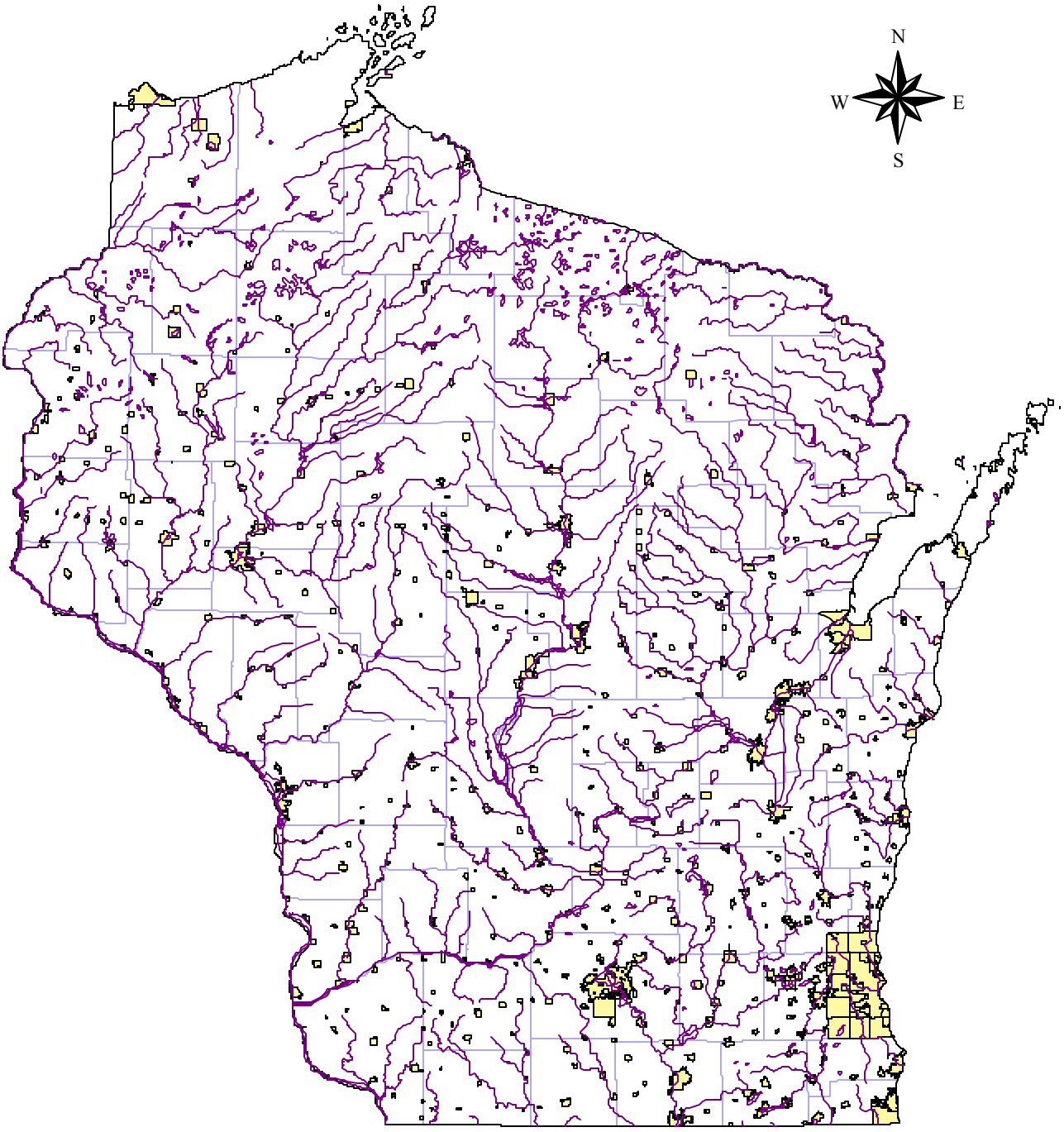
Green Bay, WI http://www.crh.noaa.gov/grb/warn.html
Serving Vilas, Forest, Florence, Marinette, Oneida, Lincoln, Langlade, Marathon, Shawano, Menominee, Oconto, Portage, Door, Kewaunee, Waushara, Winnebago, Calumet and Manitowoc Counties.

Milwaukee, WI http://www.crh.noaa.gov/mkx/
Serving Marquette, Green Lake, Fond du Lac, Sheboygan, Sauk, Dodge, Columbia, Washington, Ozaukee, Iowa, Dane, Jefferson, Waukesha, Milwaukee, Lafayette, Green, Rock, Walworth, Racine and Kenosha Counties.

La Crosse, WI http://www.crh.noaa.gov/arx/
Serving Taylor, Jackson, Trempealeau, Buffalo, La Crosse, Monroe, Juneau, Adams, Vernon, Crawford, Richland and Grant Counties.

Minneapolis, MN http://www.crh.noaa.gov/mpx/index.html
Serving Polk, Barron, Rock, St. Croix, Dunn, Chippewa, Pepin and Eau Claire Counties.

Major Rivers in Wisconsin



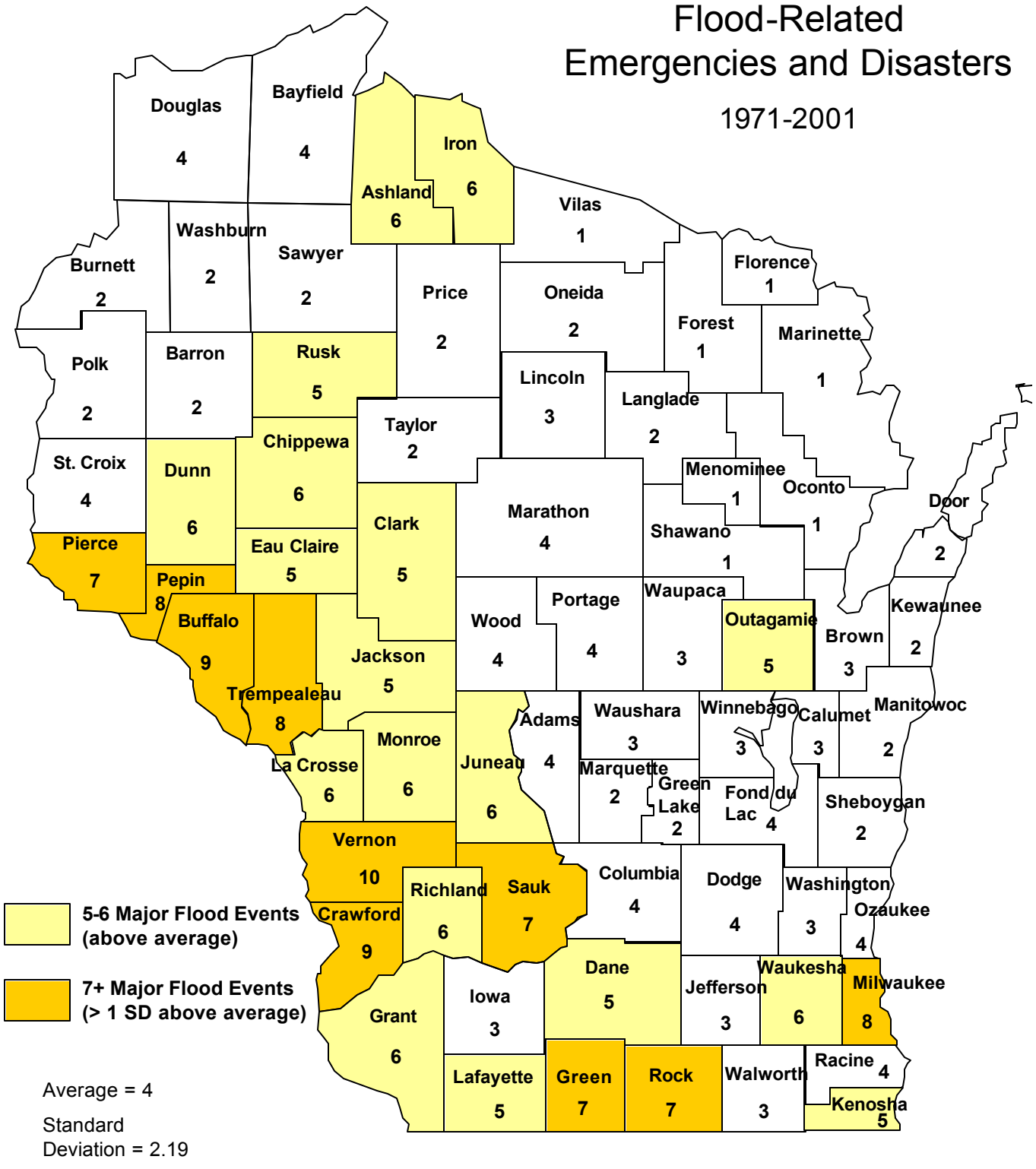
Hydrology (Major Rivers)
State Boundary
Major Cities
County Boundaries

Source: Wisconsin Department of Natural Resources

Major River Basins in Wisconsin

State Boundary
Major Cities
Major River Basins
County Boundaries

Source: Wisconsin Department of Natural Resources



Source: Wisconsin Emergency Management

FOREST FIRES AND WILDFIRES

Hazard Description: A forest fire is an uncontrolled fire occurring in a forest or in woodlands outside the limits of incorporated villages or cities. A wildfire is any instance of uncontrolled burning in brush, marshes, grasslands or field lands. For the purpose of this analysis, both of these kinds of fires are being considered together. The causes of these fires include lightning, human carelessness and arson.

Hazard Assessment: Forest fires and wildfires can occur at any time of day and during any month of the year, but the peak fire season in Wisconsin is normally from March through November. The season length and peak months may vary appreciably from year to year. Land use, vegetation, amount of combustible materials present and weather conditions such as wind, low humidity and lack of precipitation are the chief factors determining the number of fires and acreage burned. Generally, fires are more likely when vegetation is dry from a winter with little snow and/or a spring and summer with sparse rainfall.

Forest fires and wildfires are capable of causing significant injury, death and damage to property. A recent inventory showed that 46 percent of the state, 16 million acres, is covered with forests. The potential for property damage from fire increases each year as more recreational properties are developed on wooded land and increased numbers of people use these areas. Fires can extensively impact the economy of an affected area, especially the logging, recreation and tourism industries, upon which many northern counties depend. Major direct costs associated with forest fires or wildfires are the salvage and removal of downed timber and debris and the restoration of the burned area. If burned-out woodlands and grasslands are not replanted quickly to prevent widespread soil erosion, then landslides, mudflows and floods could result, compounding the damage.

Historical Frequency and Significant Incidents: The most disastrous fire in the state's history, the Peshtigo fire, occurred on October 8, 1871, when over 1,200,000 acres of forest burned in northeastern Wisconsin, mainly in Oconto, Marinette, Shawano, Brown, Kewaunee, Door and Manitowoc counties. It was estimated that 3,000 people were made homeless by this fire. With 1,152 people killed and another 350 missing, this represents the greatest single loss of human life by fire in American history. However, the Great Chicago Fire occurred at the same time and received much more publicity than this historic Wisconsin fire.

The 1976 drought created the most severe fire danger conditions in Wisconsin forests and grasslands since the 1930s. During 1976 a total of 4,144 fires occurred, the greatest number in any one-year since 1971, when detailed record keeping began. Likewise, the fire season of 1988 is also remembered as one of the driest on record. A total of 3,242 fires occurred that year, but just 9,740 acres burned, an extraordinarily low number considering the severity of the threat.

Programs: The Wisconsin Department of Natural Resources (DNR) is responsible for forest fire protection on approximately 18 million acres of forest and wild lands in the state. The U.S. Forest Service maintains fire protection responsibility for designated national forests within the state, an area of about 2 million acres. Local fire departments carry out this responsibility on the remaining wildland and forest acreage.

Both the DNR and the US Forest Service have grave concerns about the potential for severe forest fires during the fire season in 2000 and beyond. The thousands of acres of timber blown down in the downburst in late July 1999 in the northern tier of Wisconsin counties have created a potential hazard. Downed timber impedes the mobility of fire-fighting vehicles and equipment and provides large reserves of fuel if a fire should break out. The US Forest Service and the Department of Natural Resources are working together in advance of the fire season to plan strategies to reduce the risk of a severe forest fire.

The DNR Bureau of Forestry is the lead state agency in this area. It maintains a command center in Madison and monitors fire conditions throughout the state. It maintains and conducts an active fire management program for the state. To perform this function, personnel from this bureau develop two types of plans – fire program plans and fire program action plans. Fire program plans include fire prevention education and awareness campaigns, fire education conducted in schools, fire-fighting training to be conducted and other non-emergency program actions planned for the year. Fire program action plans are also developed and are used in time of emergency. They contain listings of hazard areas, maps, response actions, notification guidance, points of contact for additional assistance and mutual support, etc. Both of these types of plans are done on an annual basis and by county. The Bureau works through its six district offices to conduct local training, educational classes, coordination, response actions and assistance.

There are three major programs being conducted by the DNR to improve fire hazard response. The first is an upgrade of their 22 manual weather stations strategically located in fire hazard areas in the northern two thirds of the state. In the last year and a half eleven of these stations have been upgraded with state funds and seven others with federal funds. The upgrade enables these stations to be fully automated and provide real-time information. They constantly monitor local conditions that are converted using the National Fire Danger Program to provide current fire hazard conditions or levels.

Another relatively new program is the use of single engine air tanker (SEAT) aircraft to fight fires. This program has been used for one year and will continue to be evaluated for another two years. These airplanes operate out of the Adams-Friendship area and are used to apply environmentally safe foam that can extinguish fires and also treat potential fuel (houses, timber, etc.) to make it more fire resistant. Finally, a major training program is being evaluated for statewide use in the Lake Michigan district or northeast area. Its purpose is to prepare local fire departments in northeast Wisconsin to help out more with forest fires. This consists of 8-10 hours of concentrated forest fire training and providing personal protective equipment such as flame-resistant coveralls for the firefighters.

Future Outlook: There is potential for forest fires ahead. Unusually strong winds in northwestern Wisconsin during the month of July 1999 damaged thousands of acres of trees. The US Forest Service estimates that approximately 12,000 acres of trees were downed within a 92,000-acre area in the Washburn District (Straddling Douglas and Bayfield Counties). Another 30,000 acres were moderately damaged with less than 40% of the trees mortally damaged. The balance of the area contains scattered patches of broken and uprooted trees. The vast majority of the blow-down area has not been treated for fire or timber activities in 50 years. Under normal weather conditions the amount of downed timber

has created a fuel load of 12 to 18 tons per acre, 3 to 6 times greater than would normally be available. If drought conditions were to occur, larger fuels would actively burn and increase the available fuel load to 20 to 30 tons per acre. Under such conditions, a fire could burn so intensely that it would create wind gusts and cause a firestorm. These events would create an exceptionally dangerous environment for firefighters. Tests sponsored by the DNR confirmed that the traditional approach of attacking the fire directly using bulldozers would not be effective. In areas heavily affected by the blow-down, even the heaviest bulldozer would be ineffective. The strategy for fighting fires in this area will require support from aerial fire suppression resources (US Forest Service memo, March 2000).

Example of wind damage to trees on Lake Minocqua July 30, 1999.

As of March 2000, the US Forest Service has identified 309 structures within the Chequamegon and Nicolet National Forests in the Washburn District that are under moderate to very high risk of loss from fire. Additionally, 180 structures have been identified as falling into a category of low to moderate wildland fire risk. This level of risk is unprecedented for the urban-wildland interface in this area. Unfortunately, the fire hazard created by the downed timber will persist for many years to come until the wood is removed, burned or decomposes. Some of the fire hazard will be reduced by timber salvage operations currently being organized. Other preparations include clearing debris around forest service roads that could allow a fire to jump the firebreak the road would normally provide. Other key strategies include:

> **Prevention**: Enhanced hazard awareness for landowners and visitors; and emergency restrictions on the use of fireworks, grills, open burning and campfires.

Planning: Enhancing fire detection ability; training and exercising for local and regional firefighters; and mapping hazard areas and vulnerable structures with aerial photos and computer software.

Preparation: Acquiring additional fire suppression equipment, especially aircraft, hose trailers and large bulldozers.

These strategies may need to be implemented with a heightened sense of awareness for wildfire potential until the downed timber is removed or no longer a threat. The summer of 2000 was fairly wet and unusually cool. This helped reduce the threat of fire, although the number of acres burned, 4,582, was above average. Only 1,338 acres were burned in 2001, fewer than any year in the last 12 years. However, tornadoes and powerful straight-line winds brought even more timber down in northwest Wisconsin in 2001, especially in Burnett County. Even though the efforts to reduce the standing fuel load will continue, the potential remains for a large and difficult to manage forest fire.

Acreage Burned by Wildfires, 1990 to 2001

Year	Acres
1990	7,287
1991	1,765
1992	2,413
1993	1,365
1994	4,317
1995	2,334
1996	2,859
1997	2,488
1998	3,964
1999	5,561
2000	4,582
2001	1,338

Source: DNR - Bureau of Forestry, 2000-2002.

Wildfires in 2001

Cause	Number	Cost	Acres
Campfires	46	18,541	99.39
Debris Burn	314	129,813	578.41
Equipment	190	43,370	146.65
Incendiary	120	25,933	145.16
Lightning	22	64	6.3
Miscellaneous	262	91,257	243.52
Railroad	28	7,189	49.55
Smoking	24	12,906	68.97
Totals	1,006	$329,073	1,337.95

Source: DNR - Bureau of Forestry, 2002.

Causes of Forest Fires, Acreage Burned and Cost from 1990 to 2000

Cause	Number	Percent	Acres	Cost
Burning of brush, debris and other working fires	6,372	36.6%	14,224.9	$1,722,120
Vehicles, engines, motors and equipment	3,533	20.3%	6,782.0	$792,501
Miscellaneous (dumps, power lines, ash disposal)	2,840	16.3%	4,912.6	$694,562
Arson, all kinds	1,926	11.1%	7,741.9	$430,435
Recreational fires (campfires, fireworks)	1,517	8.7%	3,016.4	$445,405
Smoking	576	3.3%	1,410.3	$169,958
Train Related	386	2.2%	348.1	$95,238
Lightning	263	1.5%	513.1	$90,089
Total	17,413	100%	38,949.2	$4,440,306

Source: DNR- Bureau of Forestry, 2001

Forest Fires and Wildfires Over 500 Acres in Wisconsin 1976-2001

County	Acres	Date	Section	Town	Range	Descript.	Name/Area
Juneau	3,177	May 9, 1976	28	20	4E	NWSW	New Miner I
Juneau	1,507	August 28, 1976	27	18	3E	NWSE	Necedah
Portage	1,318	September 1, 1976	27	25	8E	NENW	Dewey Marsh
Portage	2,776	October 2, 1976	7	25	8E	NWSE	Range Line
Wood	1,210	November 2, 1976	29	21	6W	SESE	Shamrock
Jackson	17,590	April 27, 1977	32	21	3W	NWNW	Brockway
Jackson	6,159	April 27, 1977	9	20	3W	NWNE	Saratoga
Jackson	3,037	April 30, 1977	9	20	4W	SWSE	Airport
Washburn	13,375	April 30, 1977	6	41	13W	SWSW	Five Mile Tower
Juneau	1,551	May 8, 1977	15	20	4E	NWNW	New Miner III
Burnett	4,654	April 21, 1980	36	40	16W	SWSW	Ekdall Church
Washburn	11,418	April 22, 1980	15	39	11W	SESE	Oak Lake
Monroe	1,028	April 22, 1980	27	18	1W	SESE	Lyndon Station
Barron	565	April 9, 1987	6	34	14W	NWNW	
Iowa	967	April 17, 1988	2	8	01E	NESE	
Douglas	863	May 2, 1988	21	45	10W	SESW	Deer Print
Juneau	911	June 25, 1988	10	14	5E	NWNE	Lyndon Station III
Dodge	1553	October 15, 1988	19	12	16E	NESE	
Green Lake	4261	November 20, 1989	16	17	12E	NESW	White River
Iowa	1897	April 22, 1990	7	8	02E	NENE	
Eau Claire	553	April 23, 1994	16	26	05W	NWSE	
Fond du Lac	630	October 24, 1998	6	14	15E	SENW	
Rock	583	March 30, 1999	10	3	10E	NWNE	
Iowa	1350	April 1, 1999	5	8	02E	NWSW	

Source: DNR- Bureau of Forestry, 2000-2002.

HAILSTORMS

Hazard Description: A hailstorm is a weather condition where atmospheric water particles form into rounded or irregular masses of ice that fall to earth. Hail is a product of strong thunderstorms that frequently move across the state. Hail normally falls near the center of the moving storm along with the heaviest rain; however, the strong winds at high altitudes can blow the hailstones away from the storm center, causing unexpected hazards at places that otherwise might not appear threatened.

Hazard Assessment: Hailstones normally range from the size of a pea to that of a golf ball, but sizes larger than baseballs have occurred with the most severe storms. They form when sub-freezing temperatures cause water in thunderstorm clouds to accumulate in layers around an icy core. When strong underlying winds no longer can support their weight, the hailstones fall earthward. Hail tends to fall in swaths that may be 20-115 miles long and 5-30 miles wide. The swath is not normally a large, continuous bombardment of hail, but generally consists of a series of hail strikes that are produced by individual thunderstorm clouds traversing the same general area. Hail strikes are typically one-half mile wide and five miles long. They may partially overlap, but often leave completely undamaged gaps between them.

Hailstorms are considered formidable among the weather and climatic hazards to property and crops of the interior plains of the U.S. because they dent vehicles and structures, break windows, damage roofs and batter crops to the point that significant agricultural losses result. Serious injury and loss of human life, however, are rarely associated with hailstorms.

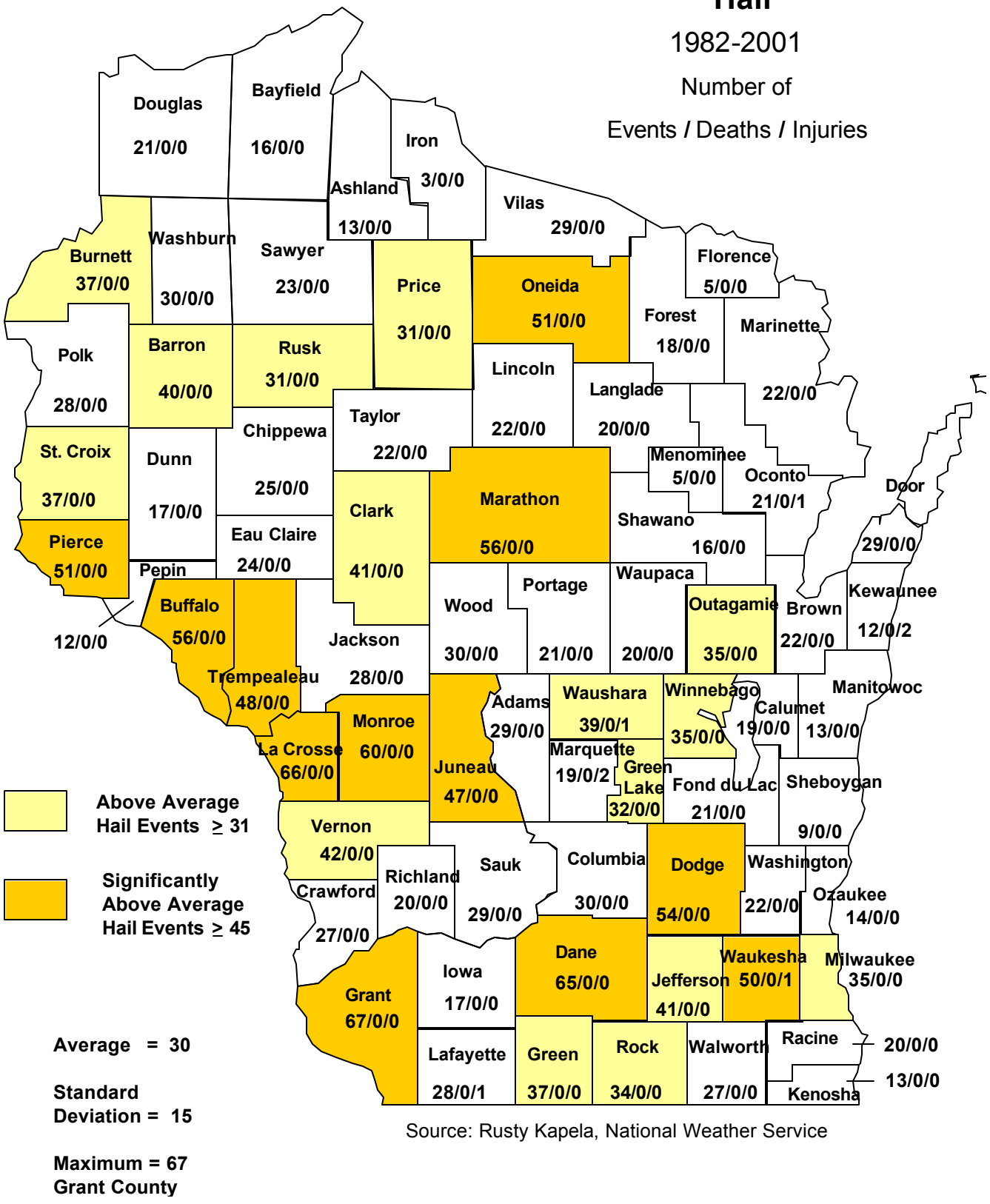
Historical Frequency and Significant Incidents: Wisconsin averages between two to three *hail days* per year as recorded by National Weather Service stations, although this may not be indicative of the number of hailstorms which occur within a county or larger area during any given hail season. The months of maximum hailstorm frequency are May through September with approximately 85% of hailstorms occurring during this period. Unfortunately, hailstorms are most frequent during the four months of the growing and harvesting seasons for most crops in the state.

According to the National Weather Service, about 20% of all severe weather events in Wisconsin are hail events in which hailstones are at least ¾ inch in diameter. Serious hailstorms with hailstones 1.5 inch or larger in diameter are not common. However, when a serious hailstorm does strike serious damage can result. Wisconsin's worst and most costly hailstorm took place on May 12, 2000 in a band of storms south of La Crosse through the Lake Winnebago area to Lake Michigan. Ten counties were pounded with hailstones 1-3 inches in diameter during the morning hours. Thirty-six people were injured and the estimated property damaged totaled $121 million.

Another very costly storm in which hail was a factor took place on July 15, 1980, when strong winds, hail and isolated tornadoes occurred across much of west central Wisconsin, causing combined agricultural and property damages of about $240 million. A Presidential Disaster Declaration was requested and issued for this incident. On July 4, 1985, storms with extensive hail traveled across Buffalo, Trempealeau, Jackson and Columbia Counties, damaging over 230,000 acres of crops and causing more than $5 million in damages. More recently, two prolific thunderstorms produced baseball and grapefruit-sized hail over a 14 county area in central and east

central Wisconsin on March 29, 1998. Over $10 million dollars in damage occurred in Waushara, Winnebago, Outagamie, Brown and Calumet Counties alone. A map showing the distribution of hail events in Wisconsin from 1982 to 2001 follows on page 44.

Resources: Hailstorms tend to occur in conjunction with severe thunderstorms, therefore severe thunderstorm weather advisories are good indicators of large or damaging hail. The Storm Prediction Center (formerly known as the National Severe Storms Forecast Center) in Kansas City, Missouri, issues severe thunderstorm watches, frequently with accompanying hail warnings, for the Midwest. Local National Weather Service offices issue watches, warnings and information statements about severe weather and localized storms, including the possibility and presence of hail. This advance warning allows some actions to reduce hail damage to vehicles and other equipment that can be garaged or similarly sheltered. Little can be done to protect structures or crops in the field. Paying attention to media weather advisories and keeping a NOAA weather radio on hand are the best ways to stay informed of potentially damaging storms including hailstorms. Information on recent local hailstorms and damages can be accessed through the National Climatic Data Center at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms.



Source: Rusty Kapela, National Weather Service

HAZARDOUS MATERIALS INCIDENTS - FIXED FACILITIES

Hazard Description: This type of hazard occurs with the uncontrolled release or threatened release of hazardous materials from a fixed site that may impact public health and safety and/or the environment.

Under the Emergency Planning and Community Right To Know Act (EPCRA), a hazardous material is defined as any chemical that is a physical hazard or health hazard [defined at 29 CFR 1910.1200(c)] for which the Occupational Safety and Health Administration (OSHA) requires a facility to maintain a Material Safety Data Sheet (MSDS). Under EPCRA there is no specific list of hazardous materials. An extremely hazardous substance (EHS) is defined as one of 356 substances on the United States Environmental Protection Agency list of extremely hazardous substances, identified at 40 CFR Part 355.

Hazard Assessment: Over the past several decades, the use of chemicals has increased in nearly every sector of the economy. As a result, hazardous materials are present in quantities of concern in business and industry, agriculture, universities, hospitals, utilities and other facilities in the state. There are no areas of the state that are exempt from a possible hazardous material incident. Despite extensive precautions taken to ensure careful handling during manufacture, transport, storage, use and disposal, accidents and inadvertent releases are bound to occur. The potential impacts of such releases include short and/or long-term health hazards to those exposed, explosions, fires and environmental contamination. An incident may also necessitate short or long-term evacuation, which disrupts the social and economic aspects of the affected area.

As of June 17, 2002, 6,778 facilities had submitted documentation to the State Emergency Response Commission indicating that they currently met the requirements of the Emergency Planning and Community Right To Know Act. Of these facilities, 3,112 submitted planning notification indicating that they had the threshold amount of at least one extremely hazardous substance.

Planning Threshold — Facility has an *extremely hazardous substance* present at any one time in an amount equal to or exceeding the chemical-specific *threshold planning quantity* (TPQ).

Reporting Threshold — Facility has 10,000 pounds of a hazardous substance or either 500 pounds or the threshold planning quantity of an extremely hazardous substance present at any one time and is not exempt from reporting requirements.

EPCRA Facilities as of June 17, 2002

Type of Facility	Number of Facilities
Planning Only	1,192
Reporting Only	3,666
Both Planning & Reporting	1,920
Total Facilities	6,778

Source: Wisconsin Emergency Management, EPCRA Section.

Significant Incidents: Wisconsin has had several significant fixed site hazardous material incidents. These include: a 250,000 gallon crude oil spill at a pumping station in Jefferson County in 1973; a 95,000 gallon gasoline spill in 1981 at a pumping station in Superior; a 1982 explosion at a chemical plant in the Duluth-Superior area that necessitated the evacuation of part of Superior; and an Oregon pool supply company fire in Dane County in December 1985 that required evacuation of part of the village. On January 6, 1996, in Lena, Oconto County, a fire in the cheese storage area of Stella Foods burned out of control. The blaze spread to the processing section of the plant and caused an ammonia release. Prior to the actual ammonia release the entire village of 590 residents was evacuated. On April 1998, hundreds of residents were evacuated in Arcadia, Trempealeau County, after a worker accidentally unloaded a tanker of cleaning acid into a storage tank containing another type of acid at the Dairy Farmers of America plant. The mixture of acids caused a chemical reaction and released a gaseous yellow cloud. Another incident occurred on January 7, 1999, when the Fox River Paper Company accidentally spilled 2000-3000 gallons of #6 fuel oil into the Fox River.

Programs: Deadly and tragic chemical releases in the United States and around the world have demonstrated the need to develop plans to handle chemical emergencies at the local level. Under the Emergency Planning and Community Right to Know Act, facilities that have quantities of hazardous materials that meet or exceed reporting thresholds are required to submit chemical inventory reports to the State Emergency Response Commission, the Local Emergency Planning committee and the local fire department.

In accordance with The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and Wisconsin Statute Chapter 166, Local Emergency Planning Committees (LEPCs) have been established in Wisconsin. Wisconsin Emergency Management has been charged with the duties of the State Emergency Response Commission and is the organization that oversees the EPCRA grant program, the emergency response system and establishing training standards for the state and the LEPCs. In this state, the federally mandated local planning districts are counties and the LEPCs develop emergency response plans and prepare for hazardous material emergencies within their individual counties. Each LEPC is required to coordinate its planning activities with local response agencies and local industries that handle extremely hazardous substances (EHS) above threshold planning quantities (TPQs), and to develop emergency response plans for the transportation of hazardous materials through their communities. Additionally, facilities are required to make emergency release notification to the National Response Center, the State EPCRA program and LEPC whenever there is a release of an "extremely hazardous substance" or other hazardous substances listed under the Comprehensive Environmental Resources and Conservation Liability Act (CERCLA).

For emergency response purposes within the state, hazardous material spill incidents are categorized as Level A or Level B releases. A *Level A release* involves the most hazardous types of materials and requires the highest degree of protection for the emergency responders, including both respiratory and skin protection. A *Level B release* requires respiratory protection with minimum skin protection. The State of Wisconsin has contracted with eight regional Level A Response Teams, to provide Level A release response capability for the state. Level B response capability is a county responsibility and there are presently 35 counties with designated Level B response teams, with remaining county teams expected to achieve designation in the near term.

HAZARDOUS MATERIALS INCIDENTS - TRANSPORTATION

Hazard Description: This hazard consists of an uncontrolled release or threatened release of hazardous materials or substances during transport that may adversely affect the public's health and safety/environment. The list of hazardous materials is extensive. However, the bulk of products being transported are petroleum products (gasoline, diesel fuel, jet fuel, fuel oil, asphalt, creosote and propane), chemicals used for industrial or manufacturing processes (anhydrous ammonia, sulfuric acid and chlorine) and waste products (industrial waste, food waste, medical waste and animal waste). There are numerous other hazardous materials routinely transported in smaller quantities such as pesticides, herbicides and specialized industrial chemicals. The majority of releases are the result of transportation accidents. However, many minor releases are the result of illegal dumping of waste materials or unwanted materials to avoid the expense of proper disposal. Transport of nuclear materials in Wisconsin does occur on occasion and will increase as the state's nuclear power plants begin shipping spent fuel to interim, private fuel storage facilities and/or to the permanent repository at Yucca Mountain, Nevada that was approved by Congress in July, 2002. Shipping to private fuel storage facilities in other states may begin in early 2004. If the Yucca Mountain plan continues on schedule, the transportation of spent nuclear fuel and high-level radioactive waste from the 131 temporary storage sites located in 39 states, including Wisconsin, will begin in 2010.

Hazard Assessment: Demand for established and new chemical substances in all walks of life result in extensive hazardous materials shipments within and through Wisconsin communities daily. The major overland modes of transportation are highways, railroads and pipelines. These modes of transport are complementary. It is common for materials to be transported by multiple modes such as pipeline to tanker truck.

Highway: Trucks are the most common way of transporting hazardous materials, accounting for as much as 94% of all hazardous materials shipments nationwide according to the USDOT. Various fuels are the most common cargo that is classified as hazardous. Every roadway in Wisconsin is a potential route for hazardous material transport. Interstate Highways 90 and 94 span Wisconsin between the densely populated Milwaukee-Chicago corridor in the southeast corner of the state and the interstate connection in north central Illinois and the west-central region along the Mississippi River. Large tankers conducting inter and intra-state transportation of hazardous materials and substances use these highways extensively. Interstate Highway 43 also provides a route for hazardous material transportation from Beloit to Milwaukee and north along Lake Michigan to the Green Bay area. Interstate 39 now provides a main transportation route of mostly petroleum products from Rockford Illinois north to Rhinelander, WI.

Rail: There are fifteen railroad companies that operate in Wisconsin, actively utilizing about 4,165 miles of track. Although trucks transport most of the hazardous materials in Wisconsin and the United States, rail can carry significantly larger and various loads. Thus, responding to rail incidents involving hazardous materials can be very dangerous due to the large quantities of materials and possible interaction among chemicals from several freight or tanker cars. Rail transport routes pass through every county in Wisconsin except Bayfield, Burnett, Door, Lafayette, Vilas and Waushara Counties.

Pipeline: There are ten major pipeline companies that operate in Wisconsin and move liquid, natural gas and oil. These pipelines are present in over 90% of the counties in the state. Most pipeline incidents involve a leak or rupture in the pipeline. These incidents are relatively limited in scope because the pipeline failure is usually partial and restricted to a single area.

Water: Wisconsin accesses world markets through 15 commercial ports located along Lake Superior, Lake Michigan and the Mississippi River. These ports transport over 40 million metric tons of cargo annually with a value of over $7 billion. There are 4 principle ports on the Great Lakes: Superior, Milwaukee, Marinette and Green Bay. Of these, the busiest port is Milwaukee, which received 807,315.2 metric tons of imported cargo and exported 396,351.6 metric tons in the year 2000 (US Dept. of Transportation, Maritime Administration statistics (www.marad.dot.gov/). However, shipments of all goods by water account for only 0.2 percent of all shipments into and out of Wisconsin and of that amount, only a portion consists of hazardous materials.

Barge traffic on the Upper Mississippi River carries freight near riverside cities and towns. Much of the barge freight is agricultural inputs such as fuel, fertilizers and other chemicals or outputs such as grain. No serious accidents or incidents have occurred involving barges or large tankers transporting hazardous materials on the Mississippi River or the Great Lakes in Wisconsin. In fact waterborne transportation is the safest and most environmentally friendly way of transporting cargo. However, the possibility for a large-scale release remains, which could have long-term environmental consequences as well as emergency public health effects.

An incident involving any one of the above modes of hazardous material transport could result in a local emergency with the potential to affect large numbers of people. The potential effects of a hazardous materials incident include health hazards to those exposed to explosions, fire, toxic gases and environmental contamination. An incident may necessitate short or long-term evacuation that would disrupt the affected area. Accidents on major transport arteries can also disrupt or stop traffic for extended periods of time.

If a hazardous materials incident occurs, public safety is always the first concern. Securing and, if necessary, evacuating the affected area is step one once it has been determined that there is a public health risk. For emergency response purposes within the state, hazardous material spill incidents are categorized as requiring either a Level A or Level B response. A *Level A response* is for the most hazardous types of materials and requires the highest degree of protection for the emergency responders, including both respiratory and skin protection. A *Level B response* requires respiratory protection with minimum skin protection. The State of Wisconsin has contracted with eight regional Level A Response Teams to provide Level A response capability for the state. There are presently 35 counties who have earned a designation of Level B Response teams. There are an additional 18 counties that have contracted with these counties to provide Level B Response services. The remaining county teams are expected to achieve designation in the near term.

There are several factors that should be considered when attempting to identify the scope, magnitude and vulnerability for incidents within different areas of the state. One factor is the density of traffic carrying hazardous materials over a specific route or through certain pipeline sections, as certain major highways, rail lines or pipelines may handle more hazardous material traffic than others. The condition of the transport routes and seasonal weather effects should also be

considered. Types and quantities of hazardous materials being transported within particular modes are of concern. However, the biggest concern is public safety and local, state and federal agencies are excellent resources for gathering commodity flow data such as the number of transportation-related incidents recorded during given time periods in given areas of the state, the type of chemical involved, the response necessary to deal with the incident, the mode of transportation involvement, etc. Developing communication between planning agencies and owner/operators can be beneficial in determining the possible risks associated with transporting hazardous materials into or through a particular community.

Significant Incidents: On March 4, 1996, Wisconsin Central Train No. 22, an 81-car train, derailed in Weyauwega. Five of the 14 cars carrying propane gas caught fire and touched off a blaze that forced the evacuation of the city and part of the surrounding area. About 2,300 people were kept out of their homes for 18 days as experts allowed the fuel to burn off safely. According to the Beloit Daily News, the train wreck cost Wisconsin Central and its insurance companies $26.1 million, including all expenses related to the evacuation and cleanup as well as settlement of legal claims (http://www.beloitdailynews.com/897/3wis9.htm). Recent transportation related hazardous material spills are summarized in the table below. The higher than average annual damages in 1996 are due to the Weyauwega incident, but do not reflect indirect costs such as evacuation and legal claims that were a financial factor in the incident. Although Weyauwega the largest incident involving an accidental release of hazardous materials, the great majority of transportation-related hazardous materials incidents take place on Wisconsin's highways.

Wisconsin Hazmat Transportation Spills

Year	Incidents					Injuries		Deaths	Damages
	Air	Hwy	Rail	Water	All	Major	Minor		
1995	1	125	2	0	128	0	2	0	$84,791
1996	4	122	2	0	128	0	2	0	$2,053,146
1997	6	129	2	0	137	0	1	0	$183,065
1998	8	178	6	0	192	0	1	0	$278,110
1999	10	233	4	0	247	1	0	0	$365,825
2000	6	235	12	0	253	0	1	1	$438,345
2001	2	290	3	0	295	0	4	4	$332,991

Source: Department of Transportation, 2002 (http://hazmat.dot.gov/files/hazmat/2001/2001frm.htm).

Programs: As mentioned previously, the State of Wisconsin has contracted with eight regional Level A Response Teams to provide Level A response capability for the state. There are presently 35 counties who have earned a designation of Level B Response teams. There are an additional 18 counties that have contracted with these counties to provide Level B Response services. The remaining county teams are expected to achieve designation in the near term. Wisconsin Emergency Management (WEM) develops policies and administers the programs that support regional emergency response teams and countywide Level B teams.

In accordance with the state and federal law, Local Emergency Planning Committees (LEPCs) coordinate planning activities with local response agencies and local industries that handle Extremely Hazardous Substances (EHSs) above Threshold Planning Quantities (TPQs). LEPCs develop off-site emergency response plans and prepare for off-site hazardous material emergencies with their counties. Planning activities include determining transportation routes to and from fixed facilities and planning for off-site consequences of transporting EHSs.

Resources: The United States Department of Transportation's (USDOT) Research and Special Programs Administration (RSPA) administers the Department's national regulatory program to assure the safe transportation of natural gas, petroleum, and other hazardous materials by pipeline. USDOT develops regulations and other approaches to risk management to assure safety in design, construction, testing, operation, maintenance, and emergency response of pipeline facilities. Since 1986, a user fee collected by USDOT funds the entire pipeline safety program. The fee is assessed on a per-mile basis on each pipeline operator USDOT regulates.

The USDOT's Office of Pipeline Safety (OPS) collects data describing pipeline safety, which is published on the OPS web site. More information about the OPS may be found at http://ops.dot.gov/index.html. The following two tables briefly summarize incidents involving natural gas transmission accidents. The data was obtained from OPS and the original data sets contain additional detail such as the time of day the incident occurred and the cause of the incident, if known. The first table describes transmission incidents in Wisconsin where there was a failure in a transmission pipeline. The second table describes incidents in Wisconsin where there was an accidental release from a local distributor of natural gas. The full data sets may be downloaded from the OPS web site at http://ops.dot.gov/IA98.htm.

Natural Gas Pipeline Transmission Incidents in Wisconsin 1984 - 2001

City	County	Date	Type	Fatalities	Injuries	Property Damage	Company
Baraboo	Sauk	21-Aug-84	Rupture	0	1	$0	Northern Natural Gas Co
Mellen	Ashland	20-Dec-93	Rupture	0	0	$750,000	Northern Natural Gas Co (Enron)
Viola	Lacrosse	17-Sep-96	Rupture	0	0	$0	Northern Natural Gas Co (Enron)
Black River Falls	Jackson	13-Oct-96	Rupture	0	0	$0	Northern Natural Gas Co (Enron)
Mauston	Juneau	29-Nov-96	Rupture	0	0	$53,750	Northern Natural Gas Co (Enron)
No data	Green	12-May-99	Rupture	0	0	$50,000	Northern Natural Gas Co (Enron)
Lena	Oconto	2-Aug-00	Rupture	0	0	$50,000	ANR Pipeline Co
Poynette	Columbia	14-Jun-01	Leak	0	0	$42,000	Northern Natural Gas Co (Enron)
Totals				0	1	$945,750	

Source: Federal Department of Transportation, Office of Pipeline Safety. 2002, (http://ops.dot.gov/IA98.htm).

Natural Gas Distribution Incident Data - 1984 to 2000

City	County	Date	Fatalities	Injuries	Property Damage
Racine	Racine	6-Sep-84	0	0	$0
Milwaukee	Milwaukee	9-Aug-84	0	2	$100,000
Delavan	Walworth	30-Oct-84	0	2	$60,000
Twin Lakes	Kenosha	6-Feb-85	0	0	$1,000,000
Green Bay	Brown	28-May-85	0	1	$40,000
Wild Rose	Waushara	10-Aug-85	1	0	$0
New Berlin	Waukesha	25-Dec-85	0	0	$0
Brodhead	Green	19-Feb-86	0	2	$0
Racine	Racine	28-Feb-86	0	0	$0
Kenosha	Kenosha	20-Jul-86	1	0	$70,000
La Crosse	La Crosse	6-Aug-86	0	2	$10,000
Wausau	Marathon	16-Oct-86	1	1	$50,000
Horicon	Dodge	13-Feb-88	0	0	$76,000
Cedar Park	Racine	26-Feb-88	0	1	$50,000
Delavan	Walworth	1-Aug-88	1	0	$0
Milwaukee	Milwaukee	24-Apr-88	0	12	$1,500,000
Nekoosa	Wood	22-Mar-89	1	2	$75,000
Menomonee Falls	Waukesha	1-Aug-89	0	1	$0
Two Rivers	Manitowoc	27-Dec-89	0	3	$100,000
Green Bay	Brown	25-Aug-90	1	0	$0
Cedarburg	Ozaukee	12-Oct-90	0	0	$80,000
Milwaukee	Milwaukee	15-Oct-90	0	0	$100,000
Summit	Waukesha	24-Jan-91	0	0	$65,000
Greendale	Milwaukee	5-Feb-91	3	6	$200,000
Eau Claire	Eau Claire	20-Feb-92	0	4	$20,000
Milwaukee	Milwaukee	9-Jul-92	0	0	$51,000
Oak Creek	Milwaukee	14-Sep-92	0	1	$0
Phillips	Price	2-Feb-93	0	1	$50,000
South Milwaukee	Milwaukee	12-Jun-93	0	0	$1,000,000
Village of Sharon	Walworth	27-Oct-93	0	1	$0
Harrison	Calumet	23-Jan-96	0	0	$150,000
Wisconsin Rapids	Wood	1-Apr-96	0	0	$70,000
Wausau	Marathon	24-Jul-96	0	0	$100,000
Madison	Dane	25-Feb-00	0	0	$200,000
Madison	Dane	16-Dec-00	0	0	$100,000
Ellington	Outagamie	3-Feb-01	1	1	$185,000
		Total	**10**	**43**	**$5.502.000**

Source: Federal Department of Transportation, Office of Pipeline Safety. 2002, (http://ops.dot.gov/IA98.htm).

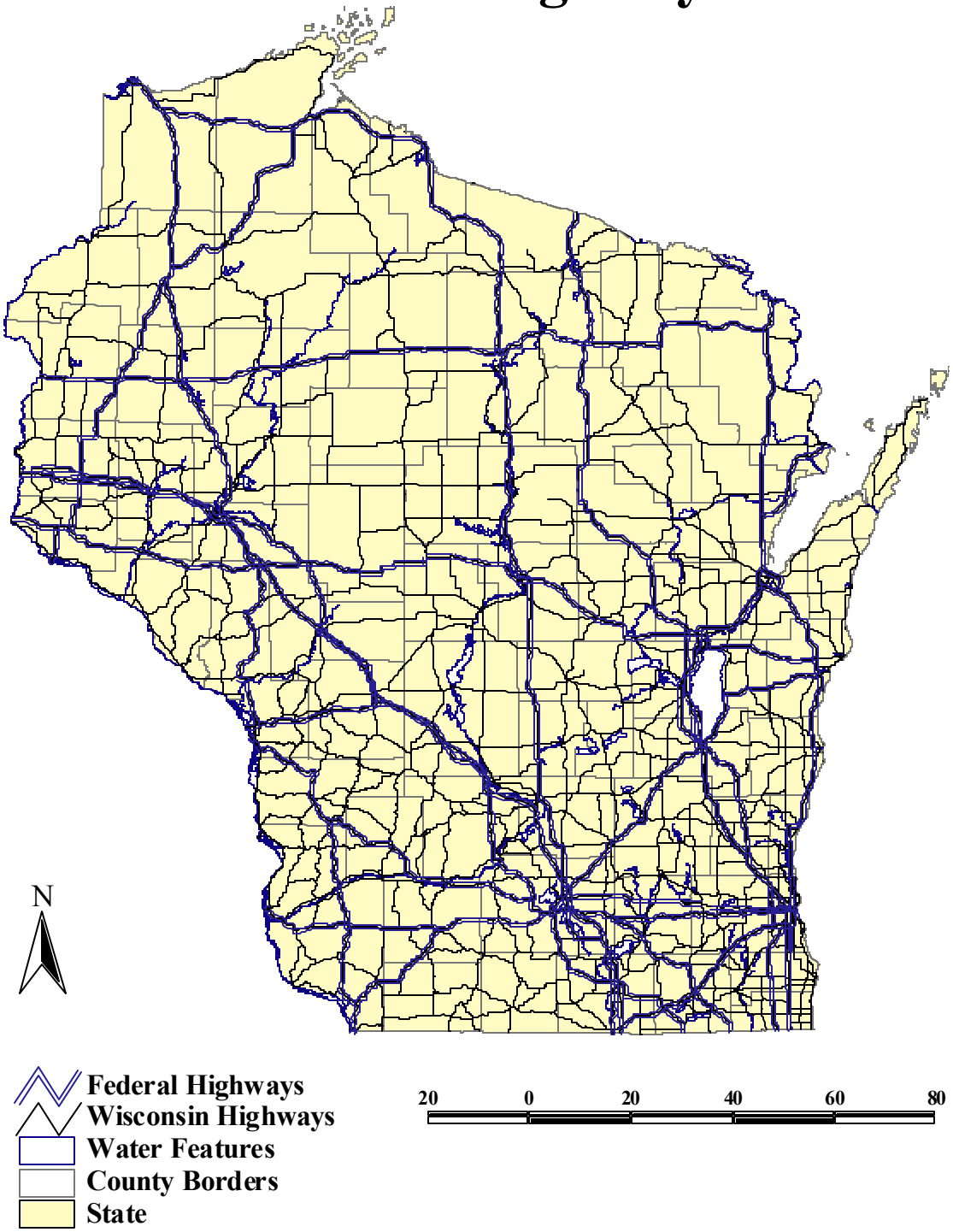
The table on the following page describes pipeline incidents involving liquids classified as hazardous, although these liquids are almost entirely various types of fuel such as gasoline, fuel oil and liquid propane gas (LPG).

Hazardous Liquid Pipeline Accident Data 1986-2001

Date	City	County	Commodity	Fatalities	Injuries	Property Damage
18-Apr-86	Green Bay	Brown	Gasoline	0	0	$0
26-Sep-86		Clark	Gasoline	0	0	$1,000
12-Mar-87	Stoughton	Dane	Fuel Oil	0	0	$60,000
27-May-87		Columbia	Crude Oil	0	0	$345,000
11-Jan-88	Superior	Douglas	Crude Oil	0	0	$5,000
04-Jun-88	Wauwatosa	Milwaukee	Fuel Oil	0	0	$0
13-Aug-90		Portage	Gasoline	0	0	$0
09-Aug-90		Racine	Gasoline	0	0	$0
15-Feb-91	Milwaukee	Milwaukee	Fuel Oil	0	0	$34,153
29-Jun-91	Unknown	Portage	Gasoline	0	0	$200,000
17-Jul-92	Superior	Douglas	Crude Oil	0	0	$50,000
24-Aug-92	Superior	Douglas	Fuel Oil	0	0	$72,000
11-Dec-92	Pleasant Valley	Eau Claire	L. P. G.	0	1	$0
22-Jun-93		Wood	Gasoline	0	0	$120,000
27-Aug-93	Milwaukee	Milwaukee	Not Given	0	0	$10,000
15-Aug-93		Clark	Fuel Oil	0	0	$100,000
15-Feb-94		Eau Claire	L. P. G.	1	1	$0
14-Mar-94		Rusk	Crude Oil	0	0	$86,000
01-Apr-94	Superior	Douglas	Crude Oil	0	0	$25,000
18-Apr-94		Lafayette	L. P. G.	0	0	$5,500
18-Dec-94	Superior	Douglas	Diesel Fuel	0	0	$3,000
02-Dec-94		Portage	Gasoline	0	0	$200,000
05-Mar-95		Eau Claire	Gasoline	0	0	$250,000
30-Aug-95		Dodge	Fuel Oil	0	0	$50,000
14-Sep-95		Dodge	Fuel Oil	0	0	$50,000
20-Sep-95		Dane	Fuel Oil	0	0	$50,000
11-Sep-95		Chippewa	Crude Oil	0	0	$75,000
11-Jun-96		Rock	L. P. G.	0	0	$95
10-Nov-96	McFarland	Dane	Gasoline	0	0	$125,000
15-Apr-97		La Fayette	Butane	0	0	$73,650
10-May-98	McFarland	Dane	Oil and Gasoline	0	0	$0
16-Jan-99	Superior	Douglas	Liq. Natural Gas	0	0	$365,000
23-Jan-99	Germantown	Washington	Gasoline	0	0	$400,000
15-Nov-99		Taylor	Oil and Gasoline	0	0	$63,800
27-Jul-00		Douglas	Crude Oil	0	0	$200,000
Totals				**1**	**2**	**$3,019,198**

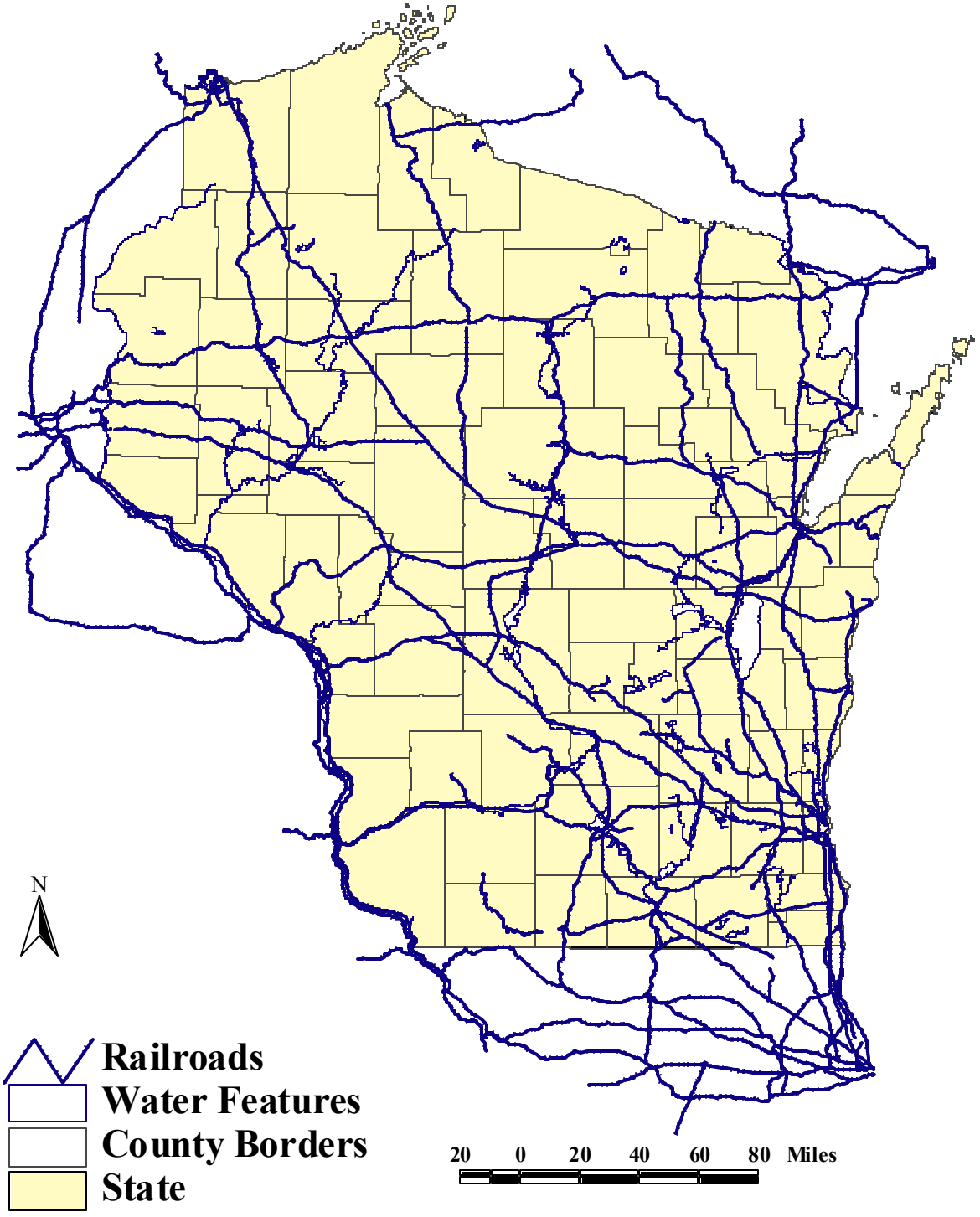
Source: Federal Department of Transportation, Office of Pipeline Safety, 2001, (http://ops.dot.gov/IA98.htm).

Wisconsin Highways



Source: Department of Administration, Office of Land Information Services.

Wisconsin Railroads



Source: Department of Administration, Office of Land Information Services.

Major Commercial Wisconsin Pipelines

1.	Badger Pipeline Company	(888) 625-7310
2.	Minnesota-Wood River & Koch	(800) 666-9047
3.	Lakehead Pipeline Company	(800) 858-5253
4.	West Shore Pipeline Company	(800) 806-2449
5.	Williams Pipeline Company	(918) 588-3200
6.	Mid-Americ Propane Pipeline	(918) 584-4471

Ports of Wisconsin

Source: Department of Administration, Office of Land Information Services.

HEAT WAVES

Hazard Description: A heat wave is primarily a public health concern. During extended periods of very high temperatures or high temperatures with high humidity, individuals can suffer a variety of ailments including heat exhaustion and heat stroke. Heat stroke in particular is a life-threatening condition that requires immediate medical attention. In addition to posing a public health hazard, periods of excessive heat usually result in high electrical consumption for air conditioning, which can cause power outages and brown outs.

Hazard Assessment: Excessive heat has become the most deadly hazard in Wisconsin in recent times. According to the National Weather Service Milwaukee/Sullivan Office, 109 people have died in Wisconsin directly as a result of heat waves during the 20 years from 1982-2001. This rate of mortality during this 20-year period is more than 4 times greater than the next most deadly hazards - tornadoes (25 deaths) and cold waves (24). The majority of deaths during a heat wave are the result of heat stroke. The elderly, disabled and debilitated are especially susceptible to heat stroke. Large and highly urbanized cities can create an island of heat that can raise the area temperature 3 to 5 degrees F. Therefore, urban communities with substantial populations of elderly, disabled and debilitated people could face a significant medical emergency during an extended period of excessive heat.

Preparedness: During the summer there are public service announcements about the health risks of heat and how to recognize the symptoms of heat stroke and heat exhaustion. Public safety workers and community volunteer organizations should be aware of elderly and shut-in populations that are at greatest risk. Emergency medical workers need to be prepared for treating heat stroke victims.

Historical Frequency: Several heat waves from mid-July through early August 2001 claimed 15 fatalities (10 direct and 5 indirect) across Wisconsin. Perhaps 300 people or more were treated at hospitals for heat exhaustion. Temperatures topped out in the mid to upper 90s. However on August 7th the temperature topped out at 102 at Mt. Mary College in Milwaukee and 101 in Buffalo and Trempealeau counties.

Another heat wave struck Wisconsin during the last two weeks of July 1999 and peaked during the 4 days of July 28-31. During these four days, high humidity and temperatures in the 90s and 100s produced heat index values of 110 to as high as 125 degrees. The heat wave resulted in 12 direct and 8 indirect deaths (National Weather Service). During this time, there was record peak demand for electric power in the Milwaukee area and for that summer there was a record set for the Midwest region for electrical demand.

During the summer of 1995, Wisconsin experienced 2 periods of prolonged heat. From June 17-27, high temperatures were well in the 90s with heat index values of 98 to 104. During this period, 9 people died directly from the heat. The second heat wave, July 12-15, resulted in the greatest number of weather-related deaths in Wisconsin history. During this heat wave, 141 people died directly or indirectly from the heat. High temperatures were between 100 and 108 with heat index values of 120 to 130. All time record high temperatures were set in La Crosse (108) on July 13, 1995, and Sheboygan (108) on July 14, 1995.

Heat Related Deaths in Wisconsin

Year	Direct Deaths	Indirect Deaths
1986	1	0
1988	1	0
1993	2	0
1995	82	72
1997	1	0
1999	12	8
2001	10	5
Totals	**109**	**85**

Source: National Weather Service, Milwaukee/Sullivan Office, 2002.

The table below displays the number of fatalities nationwide directly resulting from the heat wave of 1995 broken down by age and gender. It is worth noting that over 71% of the fatalities occurred were people aged 60 years and older. Most of the all-time maximum daily temperatures were recorded during the Dust Bowl years between 1934 and 1936. The highest temperature ever recorded in Wisconsin was 114 degrees, which occurred on July 13, 1936, at Wisconsin Dells. The second table below lists the Wisconsin cities that set all-time records for high temperatures during the Dust Bowl years:

1995 Nation-Wide Heat Related Fatalities By Age and Gender

Age Group	Female	Male	Total	Percent
0 to 9	6	6	12	1
10 to 19	0	2	2	0
20 to 29	2	3	5	0
30 to 39	7	27	34	3
40 to 49	15	64	79	8
50 to 59	22	73	95	9
60 to 69	50	129	179	18
70 to 79	131	122	253	25
80 to 89	145	96	241	24
90 and Above	51	10	61	6
Unknown	6	54	60	6
Total	435	586	1,021	100

Source: National Weather Service, http://www.nws.noaa.gov/om/95heat.htm.

All-Time High Temperatures Set During the Dust Bowl Years

City	Record High Temperature	Date
Oshkosh	107 degrees	July 13, 1936
Appleton	107 degrees	July 14, 1936
Madison	107 degrees	July 14, 1936
Milwaukee	105 degrees	July 24, 1934
Green Bay	104 degrees	July 13, 1936
Wisconsin Dells	114 degrees	July 13, 1936

Source: National Weather Service, Rusty Kapela, Milwaukee/Sullivan Office.

Programs: The National Weather Service (NWS) issues advisory statements to media, emergency management and public health officials in advance of and during conditions of excessive heat. Heat waves cannot be prevented, therefore, it is important to provide notice of adverse conditions so that the public can anticipate and avoid health-threatening situations.

Summary of National Weather Service's Alert Procedures: The NWS will initiate alert procedures (advisories or warnings) when the Heat Index (HI) is expected to have a significant impact on public safety. The expected severity of the heat wave determines whether advisories or warnings are issued. A common guideline for the issuance of excessive heat alerts is when the maximum daytime Heat Index is expected to equal or exceed 105°F and a nighttime minimum Heat Index of 80°F or above for two or more consecutive days. Some regions and municipalities are more sensitive to excessive heat than others. As a result, alert thresholds may vary from these guidelines. Excessive heat alert thresholds are being tailored at major metropolitan centers based on research results that link unusual amounts of heat-related deaths to city-specific meteorological conditions. The alert procedures are:

? Include Heat Index values in zone and city forecasts;

? Issue Special Weather Statements and/or Public Information Statements presenting a detailed discussion of (1) the extent of the hazard including Heat Index values, (2) who is most at risk, (3) safety rules for reducing the risk;

? Assist state and local health officials in preparing civil emergency messages in severe heat waves. Meteorological information from Special Weather Statements will be included as well as medical information, advice, and names and telephone numbers of health officials; and

? Release to the media and over NOAA's own Weather Radio all of the above information.

Heat Index Chart

Temp (F)	Relative Humidity (%)								
	90	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**
65	65.6	64.7	63.8	62.8	61.9	60.9	60	59.1	58.1
70	71.6	70.7	69.8	68.8	67.9	66.9	66	65.1	64.1
75	79.7	76.7	75.8	74.8	73.9	72.9	72	71.1	70.1
80	88.2	85.9	84.2	82.8	81.6	80.4	79	77.4	76.1
85	101.4	97	93.3	90.3	87.7	85.5	83.5	81.6	79.6
90	119.3	112	105.8	100.5	96.1	92.3	89.2	86.5	84.2
95	141.8	131.1	121.7	113.6	106.7	100.9	96.1	92.2	89.2
100	168.7	154	140.9	129.5	119.6	111.2	104.2	98.7	94.4
105	200	180.7	163.4	148.1	134.7	123.2	113.6	105.8	100
110	235.6	211.2	189.1	169.4	151.9	136.8	124.1	113.7	105.8
115	275.3	245.4	218	193.3	171.3	152.1	135.8	122.3	111.9
120	319.1	283.1	250	219.9	192.9	169.1	148.7	131.6	118.2

Any value less than 80 is considered comfortable. Any value greater than 90 is considered extreme.
Any value greater than 100 is considered hazardous. Any value greater than 110 is considered dangerous.
Source: National Weather Service - http://www.crh.noaa.gov/grb/educate.html.

The Milwaukee-Sullivan office of the National Weather Service offers the following 3 types of alerts for excessive heat conditions in its 30-county service area:

? **Outlook** – A narrative statement issued 2 to 4 days prior to the first day that excessive heat conditions are anticipated to notify that the potential exists for a heat wave;

? **Excessive Heat Watch** – A narrative statement issued 24 to 48 hours in advance of the first day of anticipated heat wave conditions; and

? **Excessive Heat Warning** – A warning issued within 25 hours of the first day that heat wave conditions are expected. Warning threshold values are: any 24-hour period in which daytime heat indices are expected to reach or exceed 105 for 3 hours or more, while night time heat indices are 80 or higher. Warning is issued when heat indices have reached or will reach a level where heatstroke, sunstroke, or heat exhaustion is highly likely. Elderly, sick, socially disadvantaged and medicated individuals are at a higher risk and may die, especially if they live in poorly ventilated or inner-city locations without air conditioning.

Heat Wave Safety Tips: The following safety tips can minimize the possibility of getting a heat related disorder.

Slow down: Strenuous activities should be reduced, eliminated, or rescheduled to the coolest time of the day. Individuals at risk should stay in the coolest available place, not necessarily indoors.

Dress for summer: Lightweight, light-colored clothing reflects heat and sunlight, and helps your body maintain normal temperatures.

Put less fuel on your inner fires: Foods (like proteins) that increase metabolic heat production also increase water loss.

Drink plenty of water or other nonalcoholic fluids: Your body needs water to keep cool. Drink plenty of fluids even if you don't feel thirsty. Persons who (1) have epilepsy or heart, kidney, or liver disease, (2) are on fluid restrictive diets, or (3) have a problem with fluid retention should consult a physician before increasing their consumption of fluids.

Do not drink alcoholic beverages.

Do not take salt tablets unless specified by a physician: Persons on salt restrictive diets should consult a physician before increasing their salt intake.

Spend more time in air-conditioned places: Air conditioning in homes and other buildings markedly reduces danger from the heat. If you cannot afford an air conditioner, spending some time each day (during hot weather) in an air-conditioned environment affords some protection.

Don't get too much sun: Sunburn makes the job of heat dissipation that much more difficult.

Treating Heat Related Disorders

Heat Disorder	Symptoms	First Aid
Sunburn	Redness and pain. In severe cases, swelling of skin, blisters, fever, and headaches.	Ointment for mild cases if blisters appear. If breaking occurs, apply dry sterile dressing. Serious, extensive cases should be seen by a physician.
Heat Cramps	Painful spasms usually in muscles of legs and abdomen possible. Heavy sweating.	Firm pressure on cramping muscles, or gentle massage to relieve spasm. Give sips of water. If nausea occurs, discontinue use.
Heat Exhaustion	Heavy sweating, weakness, skin cold, pale and clammy. Pulse thready. Normal temperature possible. Fainting and vomiting.	Get victim out of sun. Lie down and loosen clothing. Apply cool wet cloths. Fan or move victim to air-conditioned room. Sips of water. If nausea occurs, discontinue use. If vomiting continues, seek immediate medical attention.
Heat Stroke (or sunstroke)	High body temperature (106°F, or higher). Hot dry skin. Rapid and strong pulse. Possible unconsciousness.	Heat stroke is a severe medical emergency. Summon medical assistance or get the victim to a hospital immediately. Delay can be fatal**.** Move the victim to a cooler environment. Reduce body temperature with cold bath or sponging. Use extreme caution. Remove clothing, use fans and air conditioners. If temperature rises again, repeat process. Do not give fluids.

Source: http://www.crh.noaa.gov/grb/educate.html

Wisconsin Heat Wave Days

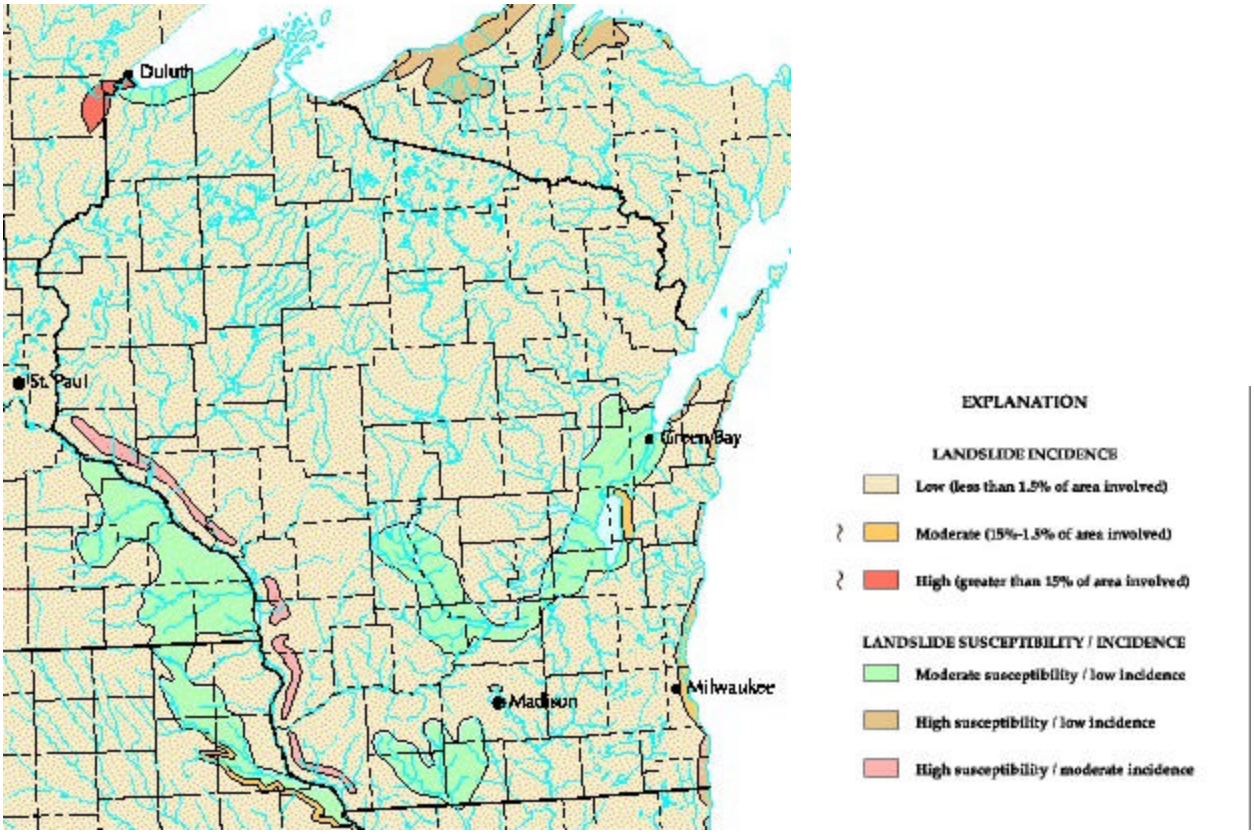
1982-2001

Source: National Weather Service, Milwaukee Office, 2002.

LANDSLIDES AND SINKHOLES

Hazard Description: Landslides and sinkholes are geological phenomena that can pose a hazard to structures and people. Although neither landslides nor sinkholes are likely to be the cause of a major natural disaster, both present risks to citizens of Wisconsin. A landslide is a relatively sudden movement of soil and bedrock downhill in response to gravity. The movement of the soil can cause damage to structures by removing the support for the foundation of a building or by falling dirt and debris colliding with or covering a structure. Landslides can be triggered by heavy rain, bank or bluff erosion, or other natural causes. A sinkhole is a depression in the ground caused by an evacuation of support from below the soil. Sinkholes can form naturally in areas with karst geology – areas that have limestone or other bedrock that can be dissolved by water.

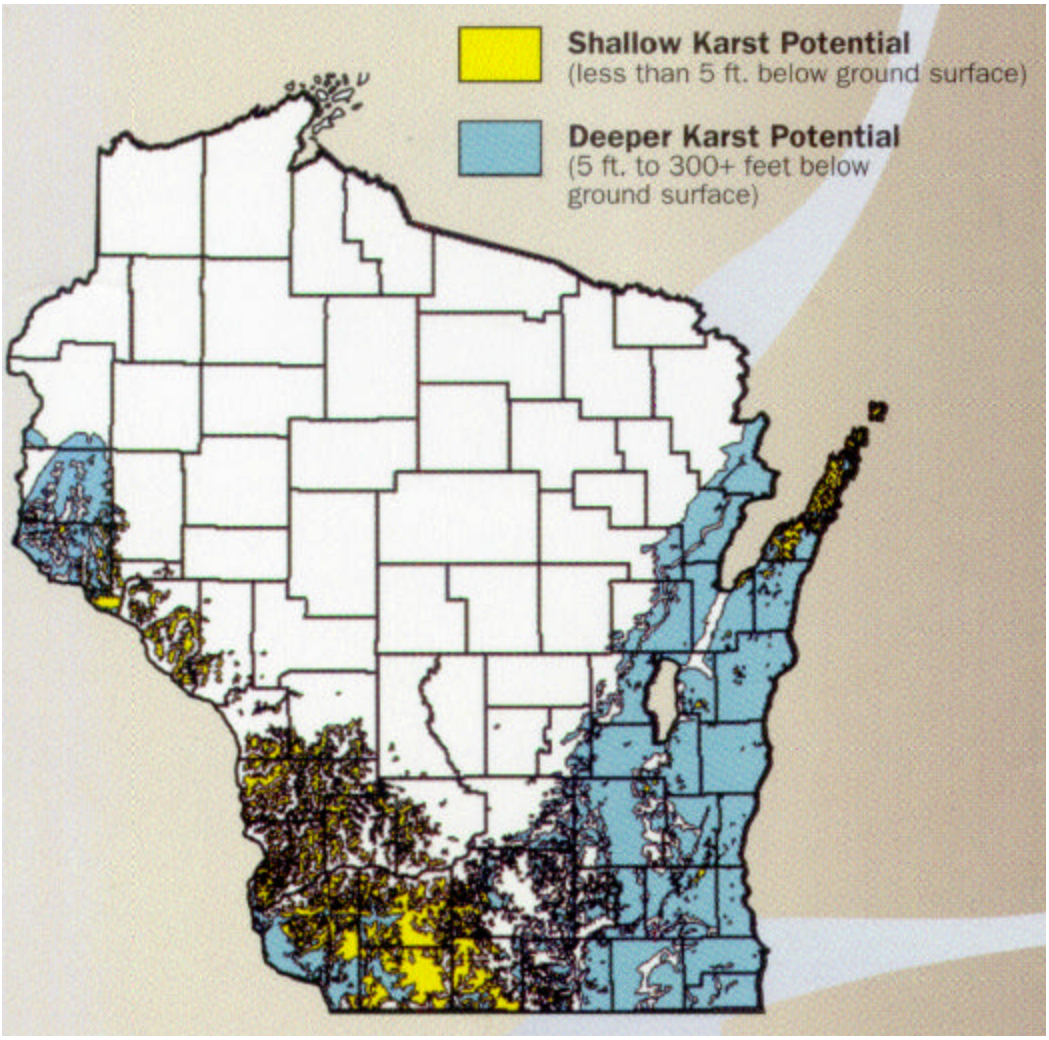
Hazard Assessment: In Wisconsin landslides generally are not dramatic. However, there have been instances of bluff slumping along the shore of Lake Michigan, rock fall along the bluffs of the Mississippi River and the collapsing of hillsides during heavy rainfall. Areas of landslide incidence are indicated in the map below.



(Source: USGS http://landslides.usgs.government/html_files/landslides/nationalmap/national.html).
Note: Susceptibility not indicated where same or lower than incidence. Susceptibility to landslides was defined as the probable degree of response of rocks and soils to natural or artificial cutting or loading of slopes, or to high precipitation. High, moderate, and low susceptibility are delimited by the same percentages used in classifying the incidence of landsliding. Some generalization was necessary at this scale, and several small areas of high incidence and susceptibility were slightly exaggerated.

Sinkholes can form naturally in areas with karst geology – areas that have limestone or other bedrock that can be dissolved by water. As the limestone rock under the soil dissolves over time

from rainfall or flowing groundwater, a hollow area may form underground, into which surface soil can sink. Sinkholes also can be caused by human activity. Some parts of southern and western Wisconsin have experienced sinkholes from abandoned underground mines that have collapsed. Identifying areas with karst conditions is important, and not just for public safety and the protection of structures. Karst features provide direct conduits to groundwater. Areas with karst conditions can be subject to groundwater contaminants from pollutants entering a sinkhole, fissure or other karst features. Areas with karst potential are indicated in the map below.



Source: Wisconsin Geological and Natural History Survey.

Hazard History: Landslides in the form of streambank erosion and hillside slumping have been a factor in several Wisconsin disasters. In 2001, a home in the City of Superior was endangered as the entire yard starting slipping downhill toward the Namdji River. Although the house was not in the floodplain and 100 yards from the river, streambank erosion from the spring floods had caused the ground within 15 feet of the house to slide downhill. The City of Superior applied for and received a Hazard Mitigation Grant under Disaster 1369 to buy the threatened structure from the landowner and demolish it to protect public safety. In 2000 during disaster 1332, one home in Grant County was damaged when its foundation partially collapsed as the hillside slumped from heavy rainfall. Falling rock is also a common problem along the bluffs of the Mississippi River.

In several areas where railroad tracks run along the river, fences have been erected with sensors to detect rockfalls that could otherwise damage or derail a train (Ron Hennings, Wisconsin Geological and Natural History Survey, 2002). According to a Wisconsin State Journal article a 400,000-pound boulder rolled down a bluff in Fountain City in July 2002, leveling trees but otherwise causing little damage. The rock was the second to fall from the bluff in the last seven years. In 1995, a 55-ton boulder crashed into a Fountain City house, causing serious damage but fortunately no injuries (WSJ July 12, 2002).

Sinkholes have not been a factor in any natural disaster. However, karst features should be identified and considered in a community especially for land use planning, stormwater management and hazardous materials planning to avoid possible damage to structures or contamination of groundwater. Even a well 100 feet deep can be contaminated from surface pollutants entering a sinkhole.

Programs: There are no state laws or programs that directly regulate or manage the hazards associated with landslides or steep terrain. Local regulation for steep slopes may be needed for some of the following public purposes: protection from natural hazards such as landslides; protection of natural resources such as water quality; and protection of environmental features like bluffs, native vegetation, and wildlife habitat. Regulations should be designed to meet local conditions and characteristics such as geology, available building space, watershed characteristics, and habitat concerns. The Village of Bayside in Milwaukee County has long had an ordinance regulating building on ravines and Lake Michigan bluffs. The Village of Cross Plains in Dane County also has an ordinance regulating building on the hills surrounding the village. Pepin County has adopted a Mississippi River Bluffland Ordinance. Copies are available from the Pepin County Zoning Administrator at (715) 672–8897. The Wisconsin Coastal Management Program encourages all coastal counties to adopt a coastal ordinance to address safety concerns such as bluff erosion as well as other coastal hazards such as flooding. For more information see the Wisconsin Coastal Management Program web site at http://www.doa.state.wi.us/dhir/boir/coastal/index.asp.

The Wisconsin Department of Natural Resources' Stewardship Program provides grants to local communities for the acquisition of land for parks or natural resource areas. Although this program does not specifically address landslide or sinkhole hazards, the Stewardship Program can be used for acquisition of land for bluff protection in areas with landslide potential or for groundwater protection in areas with karst features. For more information about WDNR's Stewardship Program see: http://www.dnr.state.wi.us/org/caer/cfa/lr/stewardship/stewardship.html#local

Resources: The Wisconsin Geological and Natural History Survey (WGNHS) is a part of the University of Wisconsin-Extension. It is an interdisciplinary organization that conducts natural resources surveys and research to produce information used for decision-making, problem solving, planning, management, development, and education. The WGNHS has produced a map of areas of karst conditions as well as other maps describing geologic features in Wisconsin. For more information contact Ronald Hennings, Assistant Director at (608) 263-7395 or by email at rghennin@facstaff.wisc.edu or visit the website at http://www.uwex.edu/wgnhs/.

The US Geological Survey has a web page at http://geohazards.cr.usgs.gov/ devoted to geologic hazards that includes links to the landslide program as well as other geological hazard programs.

LIGHTNING

Hazard Description: Lightning is a sudden and violent discharge of electricity from within a thunderstorm due to a difference in electrical charges and represents a flow of electrical current from cloud-to-cloud or cloud-to-ground. Nationally, lightning causes extensive damage to buildings and structures, kills or injures people and livestock, starts untold numbers of forest fires and wildfires and disrupts electromagnetic transmissions.

Hazard Assessment: To the general public lightning is often perceived as a minor hazard. However, lightning-caused damage, injuries and deaths establish lightning as a significant hazard associated with any thunderstorm in any part of the state. Damage from lightning occurs four ways:

(1) Electrocution/severe shock of humans and animals;
(2) Vaporization of materials along the path of the lightning strike;
(3) Fire caused by the high temperatures associated with lightning (10,000-60,000° F); and
(4) The sudden power surge that can damage electrical/electronic equipment.

Large outdoor gatherings (sporting events, concerts, campgrounds, etc.) are particularly vulnerable to lightning strikes that could result in injuries and deaths. This vulnerability underscores the importance of developing site-specific emergency procedures for these types of events, with particular emphasis on adequate early warning. Early warning of lightning hazards, combined with prudent protective actions, can greatly reduce the likelihood of lightning-related injuries and deaths.

> "Previous studies have identified patterns associated with lightning fatalities. For example, approximately 30% of persons struck by lightning die and 74% of lightning strike survivors have permanent disabilities. In addition, persons with cranial burns or leg burns from lightning are at higher risk for death than others struck by lightning. Sixty-three percent of lightning-associated deaths occur within 1 hour of injury, 92% occur during May-September and 73% occur during the afternoon and early evening. Of persons who died from lightning strikes, 52% were engaged in outdoor recreational activities and 25% were engaged in work activities. Most lightning injuries and deaths can be prevented by taking precautions (Center for Disease Control, 1998)."

Preventing Deaths and Injuries from Lightning Strikes

- When participating in outdoor activities, be aware of weather forecasts during the thunderstorm season (generally May through September).
- Because lightning often precedes rain, preparations to avoid potential lightning strikes should begin before the rain begins.
- When thunder is heard, seek shelter inside the nearest building or an enclosed vehicle (e.g., a car or truck). If shelter is not available, avoid trees or tall objects because electricity may be conducted from that object to other nearby objects or persons.
- Avoid high ground, water, open spaces and metal objects (golf clubs, umbrellas, fences and tools).
- When indoors, turn off appliances and electronic devices and remain inside until the storm passes.

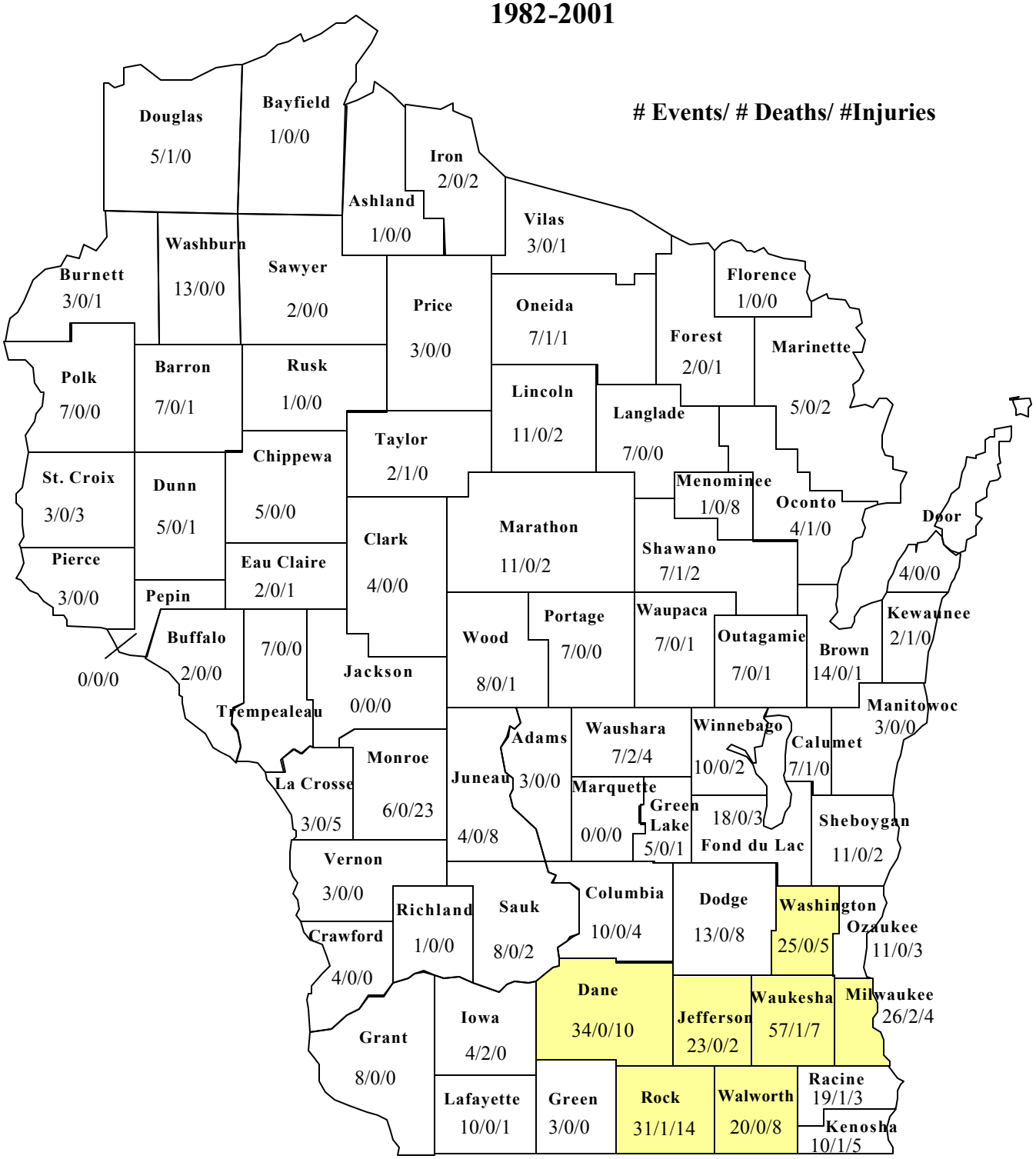
Source: Center for Disease Control, 1998.

Historical Frequency: Wisconsin has a high frequency of property losses due to lightning. Insurance statistics show that two out of every 100 farms are struck by lightning or have a fire that may have been lightning-caused each year. It is estimated that in northern Wisconsin there are between two and five lightning-caused fires per million acres of forested lands every year. In Wisconsin from 1982 to 1999 there were 18 fatalities directly caused by lightning (Rusty Kapela, NWS 2000).

Programs: The National Weather Service issues severe thunderstorm watches and warnings when there is a threat of severe weather conditions, including lightning. The National Weather Service also has an extensive public information program to educate people about the dangers of lightning and assist in preventing related deaths and injuries. Numerous other organizations provide public safety information regarding lightning, most notably the American Red Cross.

Wisconsin Lightning Events

1982-2001



Source: National Weather Service, Milwaukee Office, 2002.

NUCLEAR POWER PLANT INCIDENTS

Hazard Description: These are events that involve the uncontrolled release of potentially dangerous radioactive materials into the environment from a commercial nuclear power plant.

Hazard Assessment: Nuclear energy provides approximately 25 percent of Wisconsin's electricity, which is produced by 2 nuclear power plants (3 reactors) located in the state. There are also 2 nuclear power plants, each with 2 reactors, located in close proximity to Wisconsin, which produce electrical power for Illinois and Minnesota. (These power plants are listed in the following chart). The Nuclear Regulatory Commission (NRC) closely monitors the construction and operation of nuclear power plants, but an incident is possible. This could allow radioactive materials to contaminate the environment around a plant, which might affect the health and safety of the public living near the plant. The degree and area of environmental contamination could vary greatly depending on the type and amount of radioactivity and the existing weather conditions. An incident requires specialized emergency response personnel who have special equipment to detect and monitor radiation and have been highly trained to handle and dispose of radioactive materials safely.

Radioactive materials emit different types of radiation, each of which presents its own danger to the human body. Some types can penetrate the skin and pass through the body and others must be taken inside the body (inhalation or ingestion) to affect a person. Radiation cannot be seen, tasted, smelled or felt. The danger not only depends upon the type of radiation, but also the total amount of exposure, because radiation effects are cumulative. Greater total exposure to radiation will result in higher risk of damage to cells of the body. With nuclear power plant incidents, three dominant exposure modes to people have been identified: whole body (bone marrow) exposure from external gamma radiation, internal thyroid exposure from inhalation or ingestion of radio-iodine and internal exposure from ingestion of other radioactive materials.

Some people believe that a far greater threat posed by the plants involves the transportation of radioactive fuel and wastes to and from the plant. The interim and terminal storage of these wastes is an issue which federal, state and local officials are working to resolve.

Historical Frequency: No commercial nuclear power plant incidents have occurred that have affected the state.

Programs: Since the Three Mile Island incident in 1979, officials from federal, State of Wisconsin and local governments in nearby areas have developed detailed radiological incident response plans for each nuclear power plant. The nuclear power plants, local and state emergency management officials exercise these plans on a biennial basis and are reviewed by the Federal Emergency Management Agency (FEMA).

Response to a nuclear power plant incident in Wisconsin is a shared responsibility of the plant owner (licensee) and local, state and federal governments. Plant employees take immediate actions to control or minimize the incident, as well as required follow-up actions. State and local government agencies implement protective actions and other preparedness, response and recovery activities. The following map shows the location of each nuclear power plant affecting Wisconsin,

as well as its associated 10-mile Primary Emergency Planning Zone (EPZ) radius and 50-mile Secondary Emergency Planning Zone (EPZ) radius. These are the areas that potentially could suffer the greatest consequences of an incident at a nuclear plant and where the state focuses its Radiological Emergency Response Planning and Exercising Program (REP).

Within the primary (plume exposure pathway) EPZ, plans are developed to consider what actions are required to protect the nearby public, such as in-place sheltering and evacuation. This 10-mile distance and area could vary somewhat based on local radiological and meteorological characteristics. Falling all or partially within these zones of potential risk are Kewaunee, Manitowoc and Pierce Counties. Host counties are counties that adjoin one of the risk counties and have agreed to "host" a share of the risk county's population if a nuclear plant incident requires evacuation of the public. Wisconsin's host counties are Racine and Walworth, which support Kenosha County. Within the 50-mile secondary (ingestion exposure pathway) EPZ, planning and actions are taken to prevent the introduction of radioactive contamination into the food chain or protect the public from ingestion of contaminated materials. There are 22 Wisconsin ingestion counties, all or part of which lie within each power plant's 50-mile ingestion EPZs (see the following map and table). Risk and host counties are also considered to be ingestion counties.

When an incident occurs at a nuclear power plant, a pre-determined system is used to identify and classify the gravity of the situation. This system consists of four Emergency Classification Levels (ECLs), which are consistent with NRC and FEMA requirements and are recognized and used by the power plants and federal, state and local response organizations throughout the country. The following is a description of each of the emergency classification levels (ECLs):

Notification of Unusual Event - The first and lowest classification, which covers events that are in progress or have occurred which indicate a potential degradation of the safety level of the plant. No release is expected unless further degradation occurs.

Alert - Denotes events that are in progress or have occurred which involve an actual or potential substantial degradation in the level of plant safety. Any releases expected are limited to extremely small exposure levels.

Site Area Emergency - Reflects events that involve actual or likely major failure of plant functions needed for protection of the public. Any release resulting from an event should not exceed guideline exposure levels except near the site boundary.

General Emergency - Highest classification which denotes events that are in progress or have occurred which involve actual or imminent substantial core degradation or melting with the potential for loss of containment and release of radioactive material from the plant. Releases can be reasonably expected to exceed the guideline exposure levels offsite for more than the immediate site level.

The purpose of the first two classifications is to provide early and prompt notification of minor events, with a gradation provided to assure greater response preparations and actions for more serious indicators. The next two classification levels prompt various actions and activities that are

taken to minimize any possible effects on people, property and the environment; and provide for recovery.

The Wisconsin Radiological Incident Response Plan (WRIRP) serves as a guide for off-site response by state and local government and recovery operations. It guides the activities of eleven state agencies and other private organizations, such as the American Red Cross. Wisconsin Emergency Management has been designated by the Governor as the lead agency in coordinating the response to an incident at a nuclear power plant.

Nuclear Reactors In or Near Wisconsin

Nuclear Power Plant Name	Location	Type	Capacity-Kilowatts	Startup
Point Beach Unit 1	Two Creeks, WI	Pressurized Water	495,000	1970
Point Beach Unit 2	Two Creeks, WI	Pressurized Water	495,000	1972
Kewaunee Nuclear Power Plant	Carlton, WI	Pressurized Water	540,000	1973
Prairie Island Nuclear, Unit 1	Red Wing, MN	Pressurized Water	520,000	1973
Prairie Island Nuclear, Unit 2	Red Wing, MN	Pressurized Water	520,000	1974
Byron Unit 1	Byron, IL	Pressurized Water	1,120,000	1985
Byron Unit 2	Byron, IL	Pressurized Water	1,120,000	1986
Zion Nuclear Power Plant 1 & 2	Zion, IL	Shut down 1998		

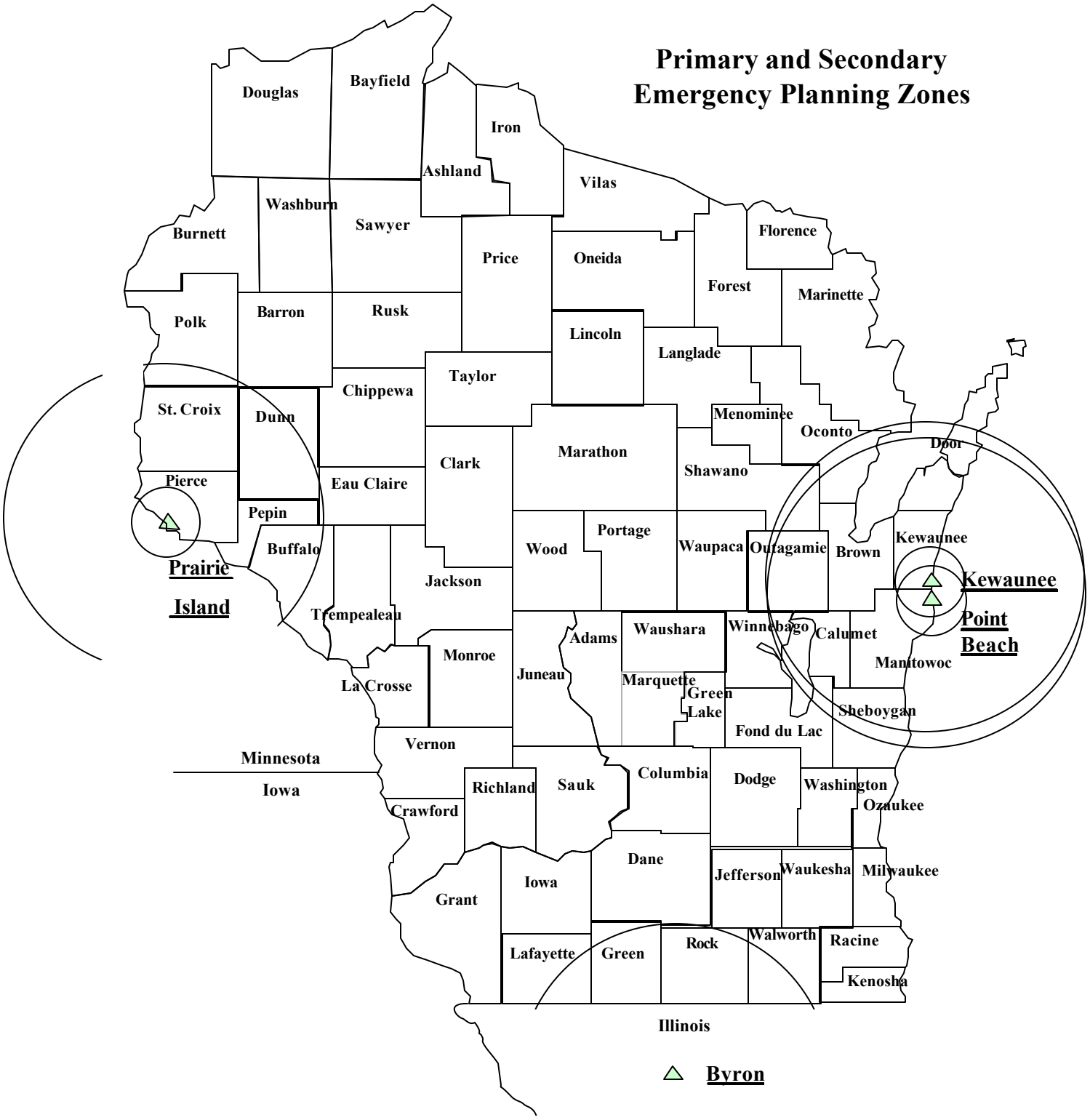
Wisconsin Counties within Possible Ingestion Pathway from a Nuclear Power Plant Incident

(Secondary Emergency Planning Zone)

County	Nuclear Plant
Brown	Kewaunee/Point Beach
Buffalo	Prairie Island
Calumet	Kewaunee/Point Beach
Door	Kewaunee/Point Beach
Dunn	Prairie Island
Fond du Lac	Kewaunee/Point Beach
Green	Byron
Kewaunee	Kewaunee/Point Beach
Lafayette	Byron
Manitowoc	Kewaunee/Point Beach
Marinette	Kewaunee/Point Beach
Oconto	Kewaunee/Point Beach
Outagamie	Kewaunee/Point Beach
Pepin	Prairie Island
Pierce	Prairie Island
Polk	Prairie Island
Rock	Byron
Shawano	Kewaunee/Point Beach
Sheboygan	Kewaunee/Point Beach
St. Croix	Prairie Island
Walworth	Byron
Winnebago	Kewaunee/Point Beach

Source: State of Wisconsin Radiological Incident Response Plan, Volume 1.

Nuclear Power Plants Affecting Wisconsin



Source: Wisconsin Emergency Management.
Note: Map is a generalized depiction of emergency planning zones created for presentation only.

PRISON/CORRECTIONAL FACILITY DISTURBANCES

Hazard Description: Prison disturbances are events that occur at correctional centers and institutions that affect the facility's security and might include any of the following inmate actions: protests, hunger strikes, rioting, widespread damage or destruction of institutional property and/or the taking of hostages. The worst-case scenarios include a "takeover" of areas of the facility by inmates or the escape of dangerous inmates into the surrounding area, with subsequent criminal acts against local citizens.

Hazard Assessment: The State of Wisconsin operates 40 correctional institutions, juvenile correctional schools and secure mental health facilities. All of the facilities, including those for juveniles, are under the auspices of the Department of Corrections and are classified as maximum, medium or minimum security. In addition to these Wisconsin facilities, there is a medium security federal correctional institution located near Oxford, in Marquette County. The names and location of these facilities are displayed on page 75.

Most prison disturbances are minor and handled by the institution's own security forces, aided by local police and county sheriff departments if requested. Each facility has a plan for calling in mutual aid if required. If the size or magnitude of the disturbance necessitates, law enforcement officials from neighboring jurisdictions and the State Patrol may be requested. National Guard personnel could also be activated and utilized, but only in correctional facility work stoppage situations.

Prison disturbances may occur for a variety of reasons such as overcrowding, perceived poor treatment, inadequate staffing, unpopular staff actions, racial strife and prisoner unrest. Disturbances are extremely dangerous from an internal perspective when hostages are taken or widespread damage or destruction of institutional property occurs. Incidents where nearby civilian populations and property are in direct danger are rare, but this is a possibility if escapes occur. Indirectly, citizens may also be impacted if emergency response personnel and resources are dedicated to the disturbance and responses to routine emergency calls are delayed.

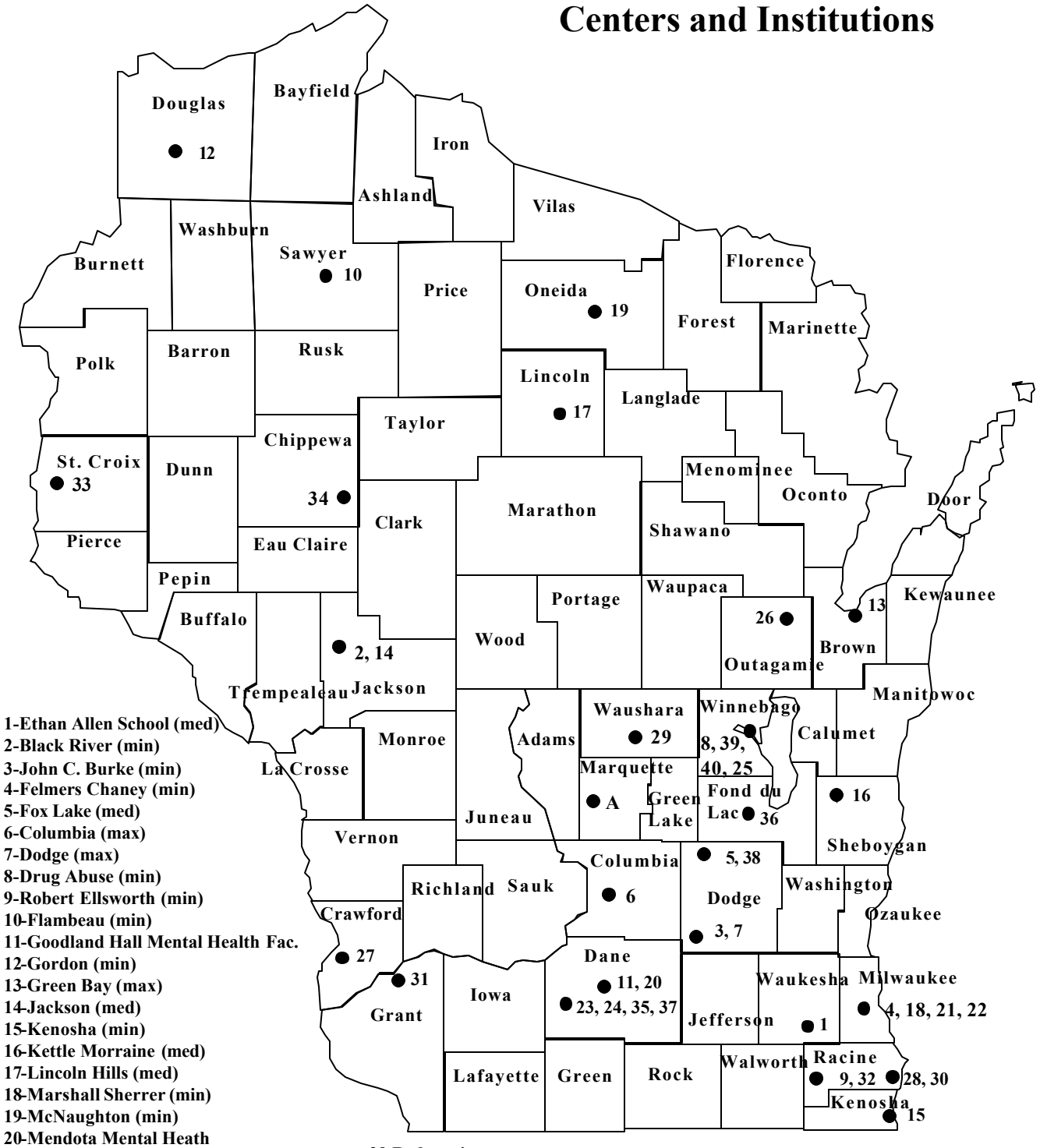
Significant Incidents: Three serious disturbances have occurred at Wisconsin correctional institutions since 1976. On July 21, 1976, 87 inmates in the Waupun facility took control of the industry building and held 14 staff personnel hostage. In addition to institution personnel, local and county authorities, the State Patrol, Emergency Management and mutual aid personnel responded quickly. Because the inmates were armed and the building was heavily fortified, this incident was settled by negotiation, with the inmates being granted amnesty. No serious injuries occurred to inmates or staff.

A second incident occurred on June 13, 1977, at the Fox Lake Correctional Institution. Inmates took 32 staff members hostage during this situation and an estimated $135,000 in damage was done to the food service, maintenance and hospital buildings. Two officers were slightly injured, but all hostages were released unharmed and the incident was resolved. In addition to facility staff, approximately sixty State Patrol, Emergency Management, Dodge County and mutual aid personnel responded, in addition to the University Hospital Trauma Unit.

The most recent serious disturbance occurred at the Waupun Correctional Institution on January 31, 1983. Fifteen members of the staff were taken hostage in two separate buildings. The emergency plan was implemented and the incident was resolved with no physical injuries to staff or inmates. However, property damage in excess of $50,000 to the facility resulted from this disturbance.

Programs: The Department of Corrections requires each facility to maintain current and up-to-date emergency plans and mutual aid agreements for use in case of disturbances or incidents. These emergency plans are reviewed and updated annually and this process includes the Department of Corrections, Emergency Police Services of the Wisconsin Emergency Management Agency, the State Patrol and local government and law enforcement agencies, in addition to officials from the facility or institution. Mutual aid agreements are also reviewed and updated on an as required basis. These plans and agreements provide for proper and rapid response in emergency situations resulting from disturbances.

Wisconsin Correctional Centers and Institutions



1-Ethan Allen School (med)
2-Black River (min)
3-John C. Burke (min)
4-Felmers Chaney (min)
5-Fox Lake (med)
6-Columbia (max)
7-Dodge (max)
8-Drug Abuse (min)
9-Robert Ellsworth (min)
10-Flambeau (min)
11-Goodland Hall Mental Health Fac.
12-Gordon (min)
13-Green Bay (max)
14-Jackson (med)
15-Kenosha (min)
16-Kettle Morraine (med)
17-Lincoln Hills (med)
18-Marshall Sherrer (min)
19-McNaughton (min)
20-Mendota Mental Heath
21-Milw. Secure Detention
22-Milw. Women's (min)
23-Oak Hill (min)
24-Oregon (min)
25-Oshkosh (med)
26-Sanger B. Powers (min)
27-Prairie du Chien (med)
28-Racine (med)
29-Redgranite
30-RYOC (med)
31-Super Max (max)
32-Southern Oaks (med)
33-St. Croix (min)
34-Stanley Correctional (med)
35-Thompson (min)
36-Taycheedah (max)
37-UW Hospital & Clinic
38-Waupun (max)
39-Winnebago (min)
40-WI Resource Ctr. (med)
A-Oxford (Federal/med)

Source: Wisconsin Emergency Management

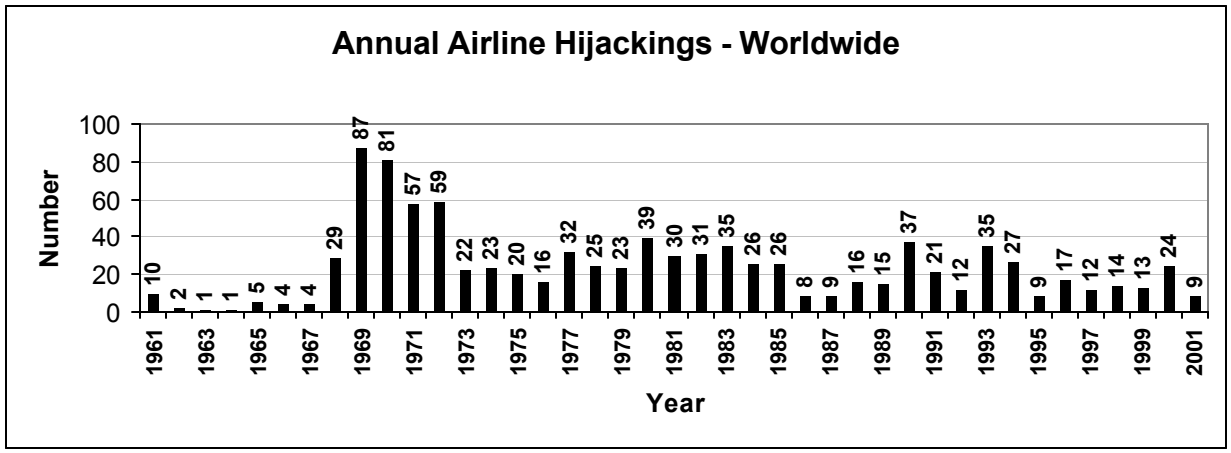
TERRORISM

Hazard Description: Terrorism can be defined as the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population or any segment of either, in the furthering of political or social objectives. The Federal Bureau of Investigation categorizes two types of terrorism in the United States: *domestic terrorism* which involves groups or individuals whose activities are directed at elements of our government or population without foreign direction; and *international terrorism* which involves groups or individuals who are foreign based and/or directed by countries or groups outside the U.S. or whose activities transcend national boundaries. Additionally, some acts conducted by gangs, people involved in civil unrest, radical splinter groups or activists and people involved in illegal drug trade could also be described as terrorism.

Hazard Assessment: An act of terrorism can take several forms, depending on the technological means available to the terrorist, the nature of the political issue motivating the act and the points of weakness of the terrorism target. Among the terrorist action possibilities are:

Bombing: Most terrorist incidents in the U.S. have involved bombs or incendiary devices, including detonated and undetonated explosive devices, tear gas, pipe and fire bombs and rocket attacks. Often the aim of the attack is to inflict large-scale damage and/or mass casualties. An example of this would be the bombing of the Murrah Federal Building in Oklahoma City in August 1995. The type of materials and method of delivery utilized in the bombing of the Murrah Federal Building are readily accessible to potential terrorists. Because of the availability of such materials, it is anticipated that various types of explosive weapons have a high potential for use in the U.S.

Airline Attack: Since September 11, 2001, there is an acute awareness of the potential use of a passenger airliner as a weapon of destruction and terror. In the past passenger airplanes often have been targets of hijacking as indicated in the graph below. There also have been instances in which airplanes have been sabotaged with bombs such as the Pan Am flight 103 that crashed in Lockerbee, Scotland in December 1988, killing 259 passengers and 11 more people on the ground.



Aviation Safety Network, 2002: http://aviation-safety.net/database/hijackings/index.html.

Other potential airplane incidents include, airport bombings or shootings or the tampering with air navigation and control systems, resulting in plane crashes or collisions.

Chemical/Biological/Nuclear Attack: Terrorists can use chemical and biological agents or weapons to either extort or deliberately try to kill in order to further political goals. An example would be the use of the toxic gas, sarin, in the attack on the Tokyo subway system that occurred in March 1995. Toxins or even some radiological materials, such as water-soluble plutonium chloride, could become a credible threat to municipal water supplies. Chemical, biological and nuclear materials weapons along with highly explosive devices are often referred to as Weapons of Mass Destruction (WMD).

Hostage Taking: The taking of hostages can provide terrorist groups publicity for their political or social objectives, allow negotiation for furtherance of their aims or result in events which are designed to invoke sympathy for their causes. The main goal of response agencies is to end the incident, with the absolute minimum loss of innocent lives. The common belief that most response agencies are willing to agree to any demand to prevent endangering the safety of hostages is not a true statement in all cases.

Infrastructure Attack: An individual or group of terrorists could coordinate an attack against utilities and other public services such as the water supply, electric power generation and transmission or telephone service. Another form of infrastructure attack is against computer resources such as databanks, communications and software by infiltrating computer networks and altering, stealing or destroying programs and data. As society becomes more dependent on computers, this form of cyber-attack is a legitimate concern. Attacks in the form of viruses, Trojan horses and worms through email or hacking have become routine for the information technology departments of many government agencies and corporations. There is evidence that cyber-attacks have been coordinated with physical attacks by terrorists in Pakistan and India (Vatis, 2001). It is likely that similar coordinated attacks will be attempted in the United States. The Federal Bureau of Investigation (FBI) has instituted a National Infrastructure Protection Center (NIPC) to investigate computer-based attacks and has made an incident report form available at http://www.nipc.gov/incident/incident.htm.

The emergency management community in the United States must accept that national security and intelligence organizations will not always be successful in preventing terrorist incidents. State and local emergency management personnel and services need to respond when attacks occur. The ramifications of responding to a terrorist incident may not be the same as traditional large-scale emergencies. The safety of emergency service providers must be an early and major consideration because a terrorist incident may present risks to responders from unknown elements or secondary attacks. In addition, the media will take an active interest in this type of incident from start to finish. The public has high expectations for emergency managers and service providers in a terrorist situation and extraordinary efforts are demanded. Federal and state government agencies depend directly on local managers and emergency response personnel and their initial and follow-up actions during any terrorist incident.

When dealing with terrorist incidents, the traditional command structure may need to be adjusted due to the inclusion of additional federal and state agencies. These additional required personnel

should be identified prior to the situation arising. The security and safety of emergency response personnel are also special concerns during terrorist incidents. The conventional procedure of treating the injured at the scene may threaten the life of the patient and emergency personnel, thus requiring the rapid evacuation of the injured from the scene before treatment begins. In addition, mass decontamination may be needed for chemical, biological or nuclear attacks.

Currently, no international terrorist groups are believed to be operating in Wisconsin, but a number of political activist, domestic terrorist and/or organized hate groups may be operating in or around the state. Potential terrorist targets include government facilities, utilities, commercial/industrial facilities, transportation centers, recreational facilities, institutions and various miscellaneous type facilities and special events. It is safe to assume that any type of facility for which an attack could generate desired publicity or further terrorism objectives could be classified as a potential target for terrorist activity.

Frequency and Significant Incidents: Wisconsin has been the target of several violent acts in the last thirty years that could be classified as terrorism or potential terrorism. On August 24, 1970, Sterling Hall at the University of Wisconsin-Madison was damaged by a bomb blast, resulting in one fatality and injuring four people. This act was conducted to protest mathematical research being conducted in the building that was funded by the US Army and thought to support the Vietnam War. On January 1, 1975, armed members of the Menominee Warriors Society took possession of the Alexian Brothers Novitiate near Gresham, holding two people hostage and demanding legal title of the property for the nearby reservation. The hostages were soon released, but the situation turned into a 35-day standoff between the Society and local law enforcement and the National Guard before resolution. During this entire standoff period, the local sheriff retained control of the response structure and activities. In November of 1997, an individual in Rock County was arrested for making the deadly toxins ricin and nicotine sulfate in his home (Milwaukee Journal Sentinel, 5/21/99). In March of 2000, activists broke into a warehouse in Vernon County that stores food for mink farms. Incendiary devices with timers were placed on a propane tank with the intent to burn the warehouse down. The devices malfunctioned and damage to the warehouse was limited to the break-in. A group calling itself the Animal Liberation Front claimed credit for the incident. (Milwaukee Journal Sentinel, 3/23/00).

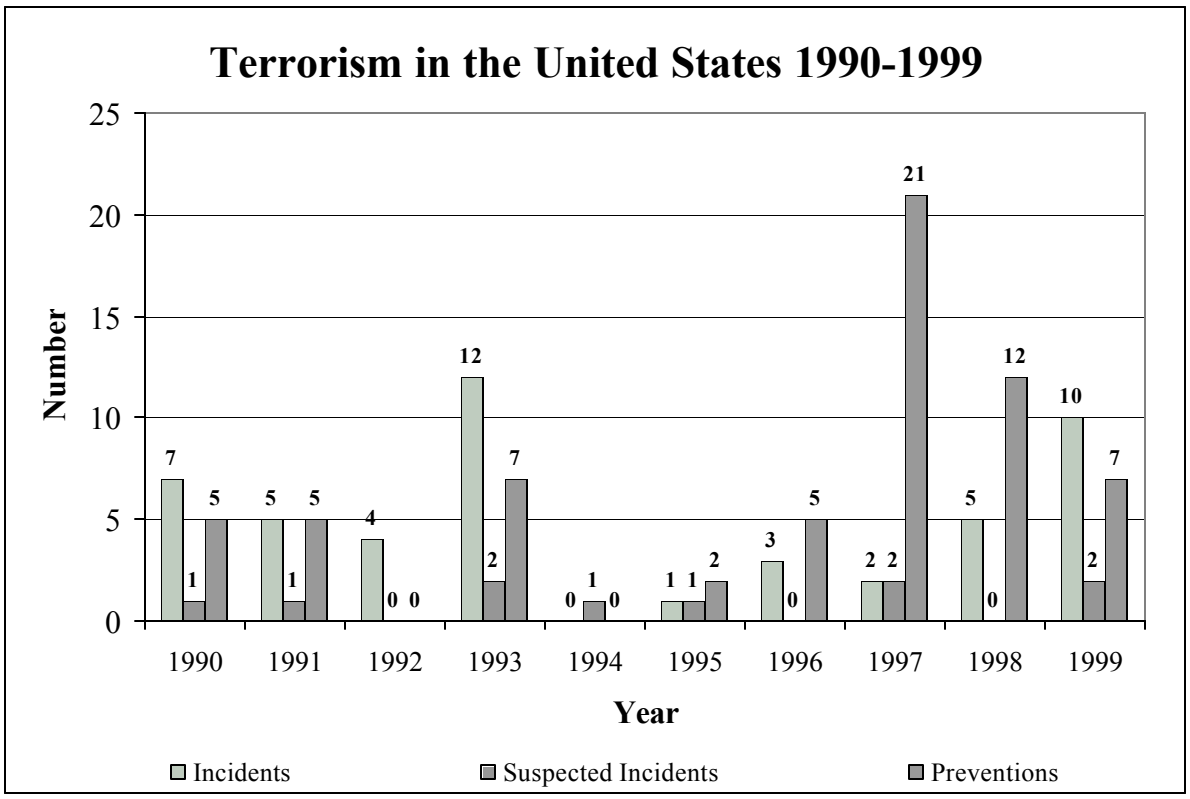
Hoaxes: A growing concern in Wisconsin is the increase in hoaxes or false alarms involving threats to public safety. For example, in January of 2000, an anthrax threat was received by a family planning clinic in Milwaukee. A day later, envelopes filled with a powdery substance were mailed to a middle school and a children's agency in Kenosha County as well as another abortion clinic on Milwaukee's east side. About 800 students at the school were evacuated and eventually sent home while 30 people, firefighters, students and staff members who were exposed to the powdery substance, which the letters claimed was anthrax, were taken to area hospitals (Milwaukee Journal Sentinel, 1/13/2000). Overall, a total of 17 letters, supposedly containing anthrax, were mailed to Milwaukee area health care clinics, planned parenthood centers, and counseling services in the month of January 2000. Although these threats and letters proved to be a hoax, responders cannot afford to treat these types of cases lightly.

Law enforcement and emergency first responders are trained to approach every threat as if it is real and potentially dangerous. For this reason, hoaxes involving threatened use of chemical,

biological and radiological substances represent a difficult challenge to public safety agencies. Although the use of Weapons of Mass Destruction (WMDs) is not common in Wisconsin, the potential loss of life from even small-scale exposure to chemical, biological or radiological substances requires caution and prudence when responding to threats involving WMD devices.

The FBI divides terrorist-related activity into three categories:

1. A *terrorist incident* is a violent act or an act dangerous to human life in violation of the criminal laws of the United States or of any state, to intimidate or coerce a government, the civilian population or any segment thereof.
2. A *suspected terrorist incident* is a potential act of terrorism to which responsibility cannot be attributed at the time to a known or suspected terrorist group or individual.
3. *Terrorism prevention* is a documented instance in which a violent act by a known or suspected terrorist group or individual with the means and a proven propensity for violence is successfully interdicted through investigative activity.



Source: Federal Bureau of Investigation, "Terrorism in the United States 1999."

During the period of 1990 through 1999, the FBI identified a total of 49 terrorist incidents, 10 suspected terrorist incidents and 64 terrorist incidents prevented in the United States. Major incidents of the 1990's include the Oklahoma City bombing on April 19, 1995, in which 168 people lost their lives. The Centennial Park bombing at the Atlanta Summer Olympics occurred

on July 27, 1996, injuring 112 people. The bombing of an Atlanta nightclub on February 21, 1997, added another element for emergency managers to consider: a secondary bomb, apparently intended for emergency responders, was discovered and disarmed at the sight of the explosion. A massive explosion occurred at the World Trade Center (WTC) complex in New York City on February 26, 1993. The blast killed six people and injured over 1,000. Property damage amounted to over half a billion dollars (Federal Bureau of Investigation, "Terrorism in the United States 1999." The most current version of this publication available is published on the Internet at www.fbi.gov/publications/terror/terroris.htm).

WMD Programs: Wisconsin anti-terrorism efforts are coordinated by the Wisconsin Emergency Management (WEM) Division within the Department of Military Affairs in cooperation with various other federal, state and local agencies. In 1997, the Governor initiated a Wisconsin Interagency Working Group on Terrorism, which includes numerous state agencies and advisory members from federal agencies. This group has been working with WEM on WMD/terrorism related issues.

Assessment and Planning: The response to terrorism is initially local, with response assistance from federal and state agencies. Therefore counties have been requested to add an Anti-Terrorism Response Appendix to their existing Emergency Operations Plan (EOP). Initially in 1999, thirteen of the largest counties in Wisconsin; Brown, Dane, Kenosha, La Crosse, Marathon, Outagamie, Racine, Rock, Sheboygan, Washington, Waukesha and Winnebago were the focus of additional training, assessment and planning efforts specifically including the development of a county WMD plan and exercises to test the plans. These counties make up 61% of the population of Wisconsin.

During FY 2000, all counties were offered the opportunity to obtain funding to conduct WMD assessments and develop county plans. The availability of funding allowed approximately 50 Wisconsin counties to receive training and begin the conduct of Weapons of Mass Destruction (WMD) assessments as part of the Department of Justice's assessment program. These assessments have continued into FY 2001 and now all 72 counties are participating. These assessments include the identification of potential targets, as well as threat and risk potentials within each county. The assessments also include determinations of the current and needed capabilities of local response agencies with regard to WMD incidents, including a review of equipment, training and exercise needs. These local evaluations and similar assessments being conducted at the state level provided the information necessary for the statewide WMD strategy, which was approved October 31, 2001.

WMD Equipment: The approval of the statewide WMD strategy means almost $3 million has been made available for local responders to purchase equipment for personal protection, detection, monitoring and decontamination, and communications to enhance response to potential WMD incidents. The U.S. Department of Justice under its Domestic Preparedness Equipment Grant Program provides equipment funding for states with which WMD response equipment can be purchased to enhance state and local response capabilities. The WMD Strategic Plan addresses WMD risks and threats and identifies a plan for purchasing and placing certain specific equipment statewide to most effectively utilize the equipment funding that is available. The WMD strategy will be updated in 2002 to enable the state to receive funding for additional types of critical equipment such as explosive device mitigation and remediation equipment, WMD technical rescue equipment,

interoperable communications equipment, medical supplies and limited types of pharmaceuticals, and general support equipment. The 2002 funding is approximately $5.9 million.

WMD Training: Since the late 1990's, the Wisconsin Technical College System through the National Fire Academy has provided WMD training. The Wisconsin Technical College System receives a Federal Emergency Management Agency funding grant to provide Weapons of Mass Destruction training to first responders. This grant provides funding for the *Emergency Response to Terrorism* series of courses developed by the National Fire Academy. Wisconsin Emergency Management in partnership with the Wisconsin Technical College System coordinates the delivery of these courses and the delivery of train-the-trainer courses to develop a cadre of instructors in the state.

In addition, Wisconsin Emergency Management has been involved in terrorism consequence management training with funding provided by the Federal Emergency Management Agency and the Department of Justice. Counties that have completed their Terrorism Consequence Management Planning Assistance (TCMPA) assessments will be eligible for training in the area of terrorism consequence management.

WMD Exercising: As counties develop their WMD plans, many are conducting local exercises to test these plans. Limited funding has been available to counties for conducting these exercises. During FY 2001-02, WEM will also be coordinating the development and conduct of WMD tabletop and functional exercises to test and further refine the state WMD plan.

Other WMD Related Activities: The U.S. Congress has passed a number of initiatives to combat terrorism, including the Nunn-Luger-Domenici Act of 1996, which funded the anti-terrorism effort. Eventually the U.S. Department of Justice was designated as the lead agency to carry out the precepts of the legislation, with assistance from many additional federal agencies.

In 1999, the Wisconsin Department of Health and Family Services received a 3-year grant for Bio-Terrorism Preparedness and Response from the U.S. Center for Disease Control and Prevention with funding for the first year of the grant set at $1.12 million. This grant provides for health alert network training, increased capability in disease surveillance and epidemiology and increased laboratory capacity for biological agents. The Department of Health and Family Services is engaged in a number of other projects relating to improving Wisconsin's ability to respond to bio-terrorism or mass-casualty events. For more information on these endeavors visit http://www.dhfs.state.wi.us/dph_bcd/Bioterrorism/BT_Partners.htm.

Resources: Wisconsin Emergency Management has some information available on its web site at http://badger.state.wi.us/agencies/dma/wem/terrorism.html for citizens who would like more information about Wisconsin's domestic preparedness.

Federal sources of information on the national response to terrorism include the following sites:

- The White House - http://www.whitehouse.gov/response/
- The Federal Bureau of Investigation - http://www.fbi.gov/terrorinfo/terrorism.htm

THUNDERSTORMS

Hazard Description: Thunderstorms are severe and violent forms of convection produced when warm moist air is overrun by dry cool air. As the warm air rises *thunderheads* (cumulo-nimbus clouds) form and cause the strong winds, lightning, thunder, hail and rain associated with these storms. The National Weather Service definition of a *severe thunderstorm* is a thunderstorm event that produces any of the following: downbursts with winds of 58 miles per hour or greater (often with gusts of 74 miles per hour or greater), hail 3/4 of an inch in diameter or greater or a tornado.

Hazard Analysis: The thunderheads formed may be a towering mass six miles or more across and 40,000 to 50,000 feet high. It may contain as much as 1.5 million tons of water and enormous amounts of energy that often are released in the form of high winds, excessive rains and three violently destructive natural elements: lightning, tornadoes and hail. This chapter will focus on the hazard of straight-line winds associated with thunderstorms since lightning, hail, tornadoes and flooding have each been covered separately elsewhere in this document.

On the ground directly beneath the storm system, the mature thunderstorm is initially felt as rain, which is soon joined by a strong downdraft. The downdraft spreads out from the cloud in gusting divergent winds and brings a marked drop in temperature. Even where the rain has not reached the ground, this cold air stream flowing over the earth's surface is a warning that the storm's most violent phase is about to mature.

A thunderstorm often lasts no more than 30 minutes in a given location because an individual thunderstorm cell frequently moves between 30 and 50 miles per hour. However, strong frontal systems may spawn more than one squall line composed of many individual thunderstorm cells. Thunderstorms may occur individually, in clusters or as a portion of a large line of storms that may stretch across the entire state. Thus, it is possible that several thunderstorms may affect an area in the course of a few hours.

Severe thunderstorms can cause injury or death and can also result in substantial property damage. They may cause power outages, disrupt telephone service and severely affect radio communications and surface/air transportation, which may seriously impair the emergency management capabilities of the affected jurisdictions.

Historical Frequency: At any given time, there are nearly 2,000 thunderstorms in progress over the earth's surface. There are at least 100,000 thunderstorms annually across the United States. In Wisconsin, thunderstorms and their associated high winds can occur throughout the state during any month of the year with little or no notice, but their highest frequency is during the period May through September. They also occur most often between the hours of noon and 10:00 p.m.

Thunderstorm frequency is measured in terms of incidence of *thunderstorm days* or days on which thunderstorms are observed. Wisconsin averages between 30 and 50 thunderstorm days per year depending on location, with the southwestern area of the state normally having more thunderstorms than the rest of the state. A given county may experience ten or more thunderstorm days per year.

According to the National Weather Service Publication, *Storm Data*, in the past 30 years, Wisconsin has experienced hurricane force winds of 75 mph or higher on 120 days or about 4 days per year on average. Within the same time period there have been 17 days when winds at or above 100 mph have been documented. This means that winds similar to a Category 2 Hurricane are experienced about one day every two years on average in Wisconsin. Thunderstorm winds can be fatal. During the period from 1982 to 2001, 20 fatalities have been attributed to wind from severe thunderstorms.

Recent Incidents: On June 11, 2001 a line of thunderstorms with many of the same characteristics as a tropical storm ripped through east-central and west central Wisconsin. The thunderstorm complex produced hurricane-strength wind gusts and hail, resulting in thousands of downed trees and damage to structures. Nearly $20 million in damage was reported in central and east-central Wisconsin. Much of the wind damage was concentrated in Wood, Portage, Waushara, Waupaca, Winnebago, Outagamie, and Calumet Counties and the cities of Appleton and Oshkosh. Overall, this event affected 30 counties, which were added to disaster declaration 1369.

Fallen trees in Oshkosh from June 11 storm 2001. Photo: Shu-Ling Zhou, Oshkosh Northwestern

Throughout the month of July 1999, the northwestern portion of Wisconsin received an unusual amount of thunderstorm activity. The cumulative damage from these events led to a disaster declaration for 10 counties. Most of the wind damage was to the forests in Douglas and Bayfield Counties. The United States Forest Service stated that downbursts and wind affected an estimated 92,000-acre area of forest during this month long period. Within this affected area approximately 12,000 acres of trees were nearly 100% down and another 30,000 acres were moderately affected with up to 40% of the trees mortally damaged. This damage has serious consequences for a number of reasons. The downed trees created an immediate debris problem on area roads as well as a severe long-term fire hazard. Other long-term effects include the spread of tree diseases that could affect the value of timber as an economic resource. Other economic losses include lost tourism, increased expenses for clearing debris and increased expense for fire fighting activities.

During the early morning hours of Sunday, May 31, 1998, south central and southeast Wisconsin experienced an unprecedented, widespread downburst wind event known as a "derecho." Incredibly powerful, hurricane-force straight-line winds, with peak gusts of 100 to 128 mph tore through 12 counties, while another 8 counties had peak gusts of 60 to 80 mph. Whereas all 20 counties in south central and southeast Wisconsin reported scattered to widespread wind damage, there were 5 main corridors or swaths of concentrated damage: 1) central Sauk County through northern Dane County through northern Jefferson County and southern Dodge County through Waukesha County and into Milwaukee County; 2) east-central Columbia County across northern Dodge County through southeast Fond du Lac County and through southern Sheboygan County; 3) West Bend area of central Washington County east to the Port Washington area of Ozaukee County; 4) southeast Iowa County into northwest Green County; and 5) northwest to central part of Lafayette County.

Utility companies and Emergency Managers stated that this was the most damaging, widespread, straight-line thunderstorm wind event to affect southern Wisconsin in the past 100 years. Estimated monetary damage for all 20 counties were $55.85 million for residential or mobile homes, businesses, utilities buildings, agriculture buildings, signs, street lights, billboards, campers and boats. There was an additional $1.48 million in crop and livestock losses. As a sign of the wind power, many concrete silos had their tops blown off and many barns flattened. Many homes and other structures had their roofs peeled off. Thousands of large trees were either uprooted or broken/twisted by the winds. Hundreds of power poles were snapped or pushed over by the winds or falling trees/branches. At one time, about 60,000 customers were without electricity in south central Wisconsin and about 170,000 in southeast Wisconsin. Some residences or businesses were without power for as much as 5 or 6 days due to a deluge of utility repairs and shortage of replacement power poles. Hundreds of motor vehicles were either damaged or totaled by falling trees/branches or collapsed garages. The monetary damage to motor vehicles is not included in the totals given above. In addition, numerous vehicle accidents resulted from inoperative stop/go streetlights, as roads quickly became logjams (Source: NOAA at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~ShowEvent~146585)."

Programs: Wisconsin Emergency Management, in conjunction with the National Weather Service and state and local government agencies provides both preparedness information and severe weather information to the citizens of Wisconsin. Preparedness information is provided during three severe weather awareness campaigns conducted during the year, each focusing on the prevalent weather hazard at that time. Each April, Tornado Awareness Week is conducted in cooperation with the Department of Public Instruction educating schools and the public on tornado hazards and safety actions. During this time extensive information is also distributed on related weather events such as severe thunderstorms.

In the event of severe weather, weather bulletins are posted. A *severe thunderstorm watch* announces that conditions are favorable for storms in and close to the watch area and implies that people should be alert for these severe storms and have a plan of action if they threaten. These watches are issued by the Storm Prediction Center in Kansas City for the Midwest. A *severe thunderstorm warning* is given when a severe storm or tornado has been detected by radar or observed by trained spotters, the storm has winds of 58 miles per hour or greater and/or produces

hail 3/4 inch or larger and people in the path of the storm should take actions to protect life and property. The National Weather Service issues these warnings.

These severe thunderstorm watch and warning bulletins and advisories are disseminated over a number of telecommunication channels, including NOAA Weather Radio, the NOAA Weather Wire and the State Law Enforcement TIME System. NOAA Weather Radio is available to any individual with a weather alert radio. This system and the other sources are routinely monitored by local media, which rebroadcast the weather bulletins over public and private television and radio stations.

Wisconsin Thunderstorm Facts:

- Wisconsin averages over 30 days each year with thunderstorms.
- One of the country's worst thunderstorm windstorms occurred on July 4, 1977, in northern Wisconsin. Winds reached more than 115 mph in a swath over 150 miles long, flattening hundreds of thousands of acres of forest.
- In 1998, thunderstorm winds were responsible for 1 death and 59 injuries in Wisconsin, mostly due to the widespread thunderstorm wind event on May 30th and 31st across southern and central parts of the state. Maximum wind gusts ranged from 80 to 128 mph!!!
- In 1999, thunderstorm winds resulted in 2 deaths, and 4 injuries in Wisconsin.

What You Can Do:

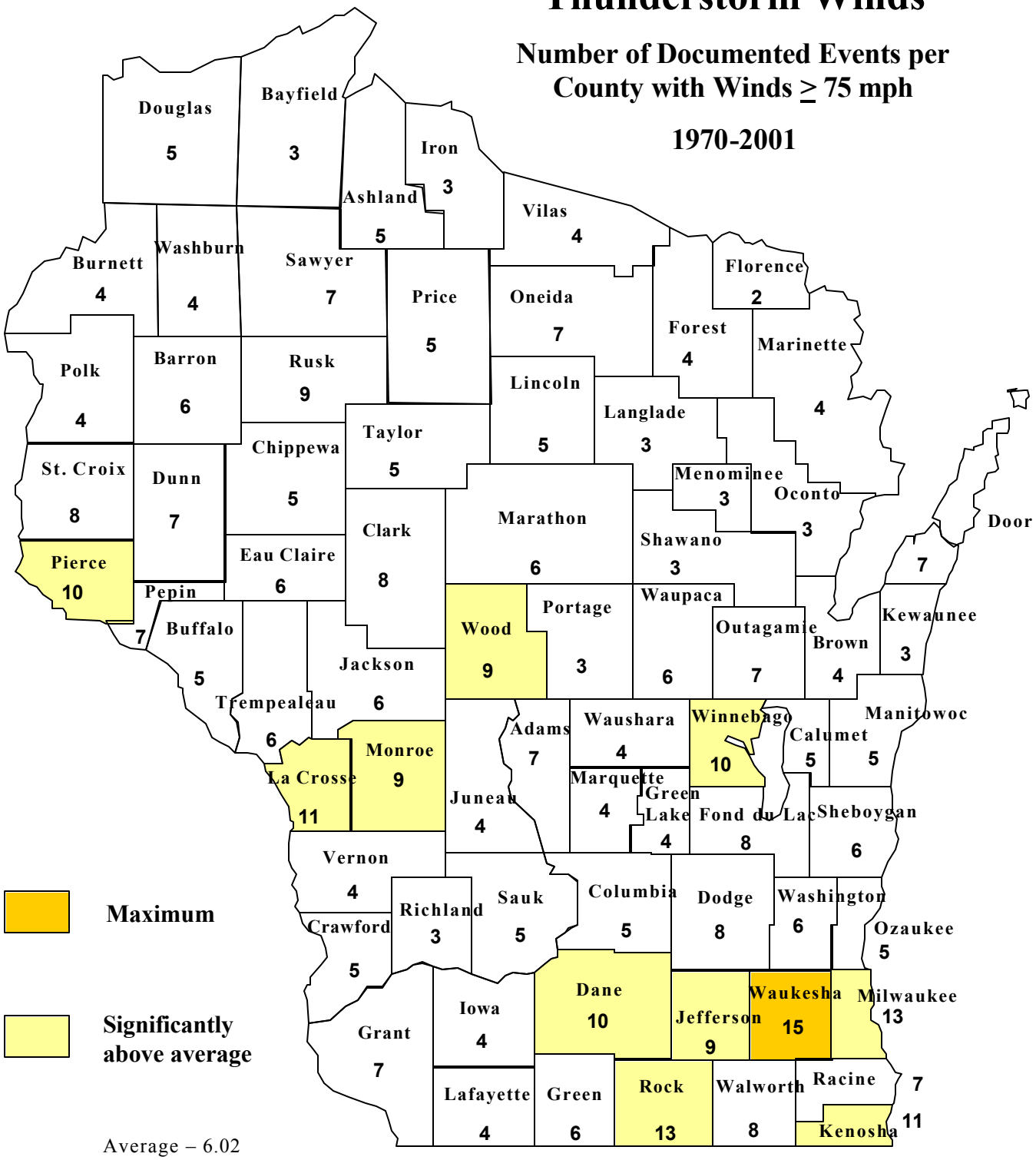
- Keep track of what county you are in. Severe weather warnings are issued on a county basis.
- Check the weather forecast before leaving for extended periods outdoors.
- If a storm is approaching, seek a sturdy shelter and keep a NOAA Weather Radio with you.
- Postpone outdoor activities if thunderstorms are imminent.
- Stay off the water if a thunderstorm approaches.
- Don't take Severe Thunderstorm Warnings lightly!

Source: National Weather Service, Milwaukee, URL: http://www.crh.noaa.gov/mkx/flyers/flyerstm.htm

Hurricane-Force Thunderstorm Winds

Number of Documented Events per County with Winds ≥ 75 mph

1970-2001



Average – 6.02

Std. Deviation – 2.67

Source: Rusty Kapela, National Weather Service, Milwaukee/Sullivan Forecast Office, 2002.

TORNADOES

Hazard Description: A tornado is a relatively short-lived storm composed of an intense rotating column of air, extending from a thunderstorm cloud system. It is nearly always visible as a funnel, although its lower end does not necessarily touch the ground. Average winds in a tornado, although never accurately measured, are between 100 and 200 miles per hour, but some may have winds exceeding 300 miles per hour. For standardization, the following are National Weather Service definitions of a tornado and associated terms:

- *Tornado* - A violently rotating column of air that is touching the ground.
- *Funnel cloud* - A rapidly rotating column of air that does not touch the ground.
- *Downburst* - A strong downdraft, initiated by a thunderstorm, which induces an outburst of straight-line winds on or near the ground. They may last anywhere from a few minutes in small-scale microbursts to periods of up to 20 minutes in larger, longer macro-bursts. Wind speeds in downbursts can reach 150 mph, in the range of a tornado.

Hazard Assessment: A tornado path averages four miles, but may reach up to 300 miles in length. Widths average 300-400 yards, but severe tornadoes have cut swaths a mile or more in width, or have formed groups of two or three funnels traveling together. On the average, tornadoes move between 25 and 45 miles per hour, but speeds over land of up to 70 mph have been reported. Tornadoes rarely last more than a couple of minutes over a spot or more than 15-20 minutes in a ten-mile area, but their short periods of existence do not limit their devastation of an area.

The destructive power of the tornado results primarily from its high wind velocities and sudden changes in pressure. Wind and pressure differentials probably account for 90 percent of tornado-caused damage. Since tornadoes are generally associated with severe storm systems, they are usually accompanied by hail, torrential rain and intense lightning. Depending on their intensity, tornadoes can uproot trees, down power lines and destroy buildings. Flying debris can cause serious injury and death.

Downbursts are characterized by straight-line winds. Downburst damage is often highly localized and resembles that of tornadoes. There are significant interactions between tornadoes and downbursts and a tornado's path can also be affected by downbursts. Because of this, the path of a tornado can be very unpredictable, including veering right and left or even a U-turn.

Wisconsin lies along the northern edge of the nation's maximum frequency belt for tornadoes, called "tornado alley" by some, which extends northeastward from Oklahoma into Iowa and then across to Michigan and Ohio. Broadly speaking, the southern and the western portions of Wisconsin have a higher frequency of tornadoes, however, every county in Wisconsin has had tornadoes and is susceptible to a tornado disaster.

Historical Frequency and Significant Incidents: While all Wisconsin counties have recorded at least two tornadoes in the period from 1844-2001, several counties, Barron, Clark, Chippewa, Dane, Dodge, Fond du Lac, Grant, Marathon, Polk, Rock and Waukesha, have each recorded 30 or more

tornadoes. Dane, Dodge and Grant Counties have had the most with 52, 51 and 50 respectively. The map on page 92 displays the total number of tornado occurrences by county for this period.

Wisconsin currently averages 20 reported tornadoes per year. For the past few years, Wisconsin has ranked about fifteenth in the nation insofar as number of annually reported tornadoes. The state ranked fourth nationally in 1980 when 43 tornadoes touched down. During 1999, there were only eleven "confirmed" tornadoes in Wisconsin, a small number compared to an average year. These occurred in Jefferson, Waukesha, Wood, Lincoln, Buffalo, St. Croix, Polk, Barron, Washburn and Rusk Counties. A more typical year would be 2000 in which there were 18 tornadoes or 1998 when there were 24 reported tornadoes. In 2001 there were 12 tornadoes. The locations, intensities and paths of the tornadoes for the past two years are shown on maps on pages 93 and 94.

Tornadoes most frequently occur in the late afternoon and early evening, but can occur at any time. As many as 75 percent of all Wisconsin tornadoes happen between the hours of 3:00 p.m. and 7:00 p.m. Tornadoes also display a strong local seasonal variation. In Wisconsin, they have occurred in every month except February, with most activity occurring between April and September. The month of June has the highest tornado frequency. The most severe tornadoes tend to occur during April, May and June with tornadoes during the remainder of the year as a rule being smaller and with shorter tracks. Winter, spring and fall tornadoes historically are more likely to occur in southern Wisconsin than in the central or northern parts of the state.

Some of Wisconsin's more noteworthy tornadoes and associated downbursts occurred as long as 100 years ago. In 1899 half of the City of New Richmond in St. Croix County was destroyed and 112 people were killed by a powerful tornado. In September 1924, 26 people were killed as a tornado ripped a path from Eau Claire County through to Oneida County.

The Berlin Tornado: On April 3, 1956, a tornado struck the southeast sector of the City of Berlin, Green Lake County at approximately 1:40 p.m. after damaging at least three farms south and west of the city. It came within a few yards of the high school where four hundred students were in class. The terrified students watched the tornado churn towards the high school, but the funnel veered to the right, barely missing the school. Witnesses saw cars and buildings lifted and carried through the air. The tornado killed 7 people and injured 50. Damage was estimated at over $1,000,000.

On June 4, 1958, 20 people died, 110 were injured and 60 buildings were destroyed in the City of Colfax in Dunn County by a tornado estimated to be F4 intensity. The same storm system produced three other tornadoes in Chippewa and Clark counties that same day. On April 21, 1974, a tornado estimated to be a F4 intensity hit the City of Oshkosh in Winnebago County. Despite a lack of no warning in advance of the storm no one was killed, although seventeen people were reported injured. Eleven commercial structures were damaged and property damage reached 4 million dollars. The hardest hit area was the section on the south by Witzel Avenue and the east close to Titan Stadium. About the time the tornado began ripping through Oshkosh in Winnebago County, a series of tornadoes touched down in Dodge County in the Lomira/Brownsville area. They left in their wake a trail of broken homes and barns and destroyed a large lumberyard. Two deaths and numerous injuries were attributed to the storms. In 1980, tornadoes and downbursts occurred in Chippewa, Dunn, Eau Claire and Pierce Counties and caused more than $150 million in property damage.

In 1984, the year of the "killer tornado", twelve Wisconsin people lost their lives as a result of severe weather. On April 27-28, 1984, three people were killed and several dozen injured when tornadoes struck Oneida, Vilas and Menominee Counties. Nine persons were killed on June 8, 1984, when tornadoes occurred in Dane and Iowa Counties and literally destroyed the Village of Barneveld. Property damage for both incidents totaled more than $50 million. Because of its intensity, the National Weather Service has studied the June 8 tornado extensively.

On August 29, 1992, severe thunderstorms developed across Wisconsin and spawned tornadoes, high winds, heavy rains, frequent lightning strikes and hail. The storms traveled eastward in Waushara County and funnel clouds set down in and around the Wautoma area just after 8:00 p.m. One death was attributed directly to the tornadoes and a second occurred as a result of a heart attack. Over thirty were transported to area hospitals with injuries (four in critical condition). Additional people, estimated in the hundreds, were also injured but they did not require professional medical treatment. A search was conducted throughout the evening by law enforcement, fire and emergency medical personnel to ensure that all victims had been found. The large number of downed trees and power lines made search and rescue efforts difficult. Over 40 homes were destroyed, with 95 more suffering major damage and almost another 400 being affected or having minor damage. A total of 28 businesses were damaged as well as numerous farm buildings. A migrant worker camp was severely damaged and a senior citizen center was demolished. Thousands of mature trees in the area were leveled and the high winds and tornadoes flattened many acres of corn and sweet corn. Some of the most devastating losses were the many stands of timber, which were severely damaged or completely destroyed.

On July 18, 1996, a line of thunderstorms caused the National Weather Service to issue a tornado watch for the eastern two-thirds of the state. As the line moved east the storms became more severe in counties such as Marathon and Portage. By the time the storms reached Fond du Lac County they had become very dangerous. At approximately 7:08 p.m. warning sirens sounded in the Village of Oakfield (population 1,005) in Fond du Lac County. At 7:13 p.m. a tornado of F5 intensity tore through the community and neighboring areas. The tornado left a path of destruction 15 miles long and a quarter to a half-mile wide. More than 19 people were injured and over 150 homes and businesses were damaged or destroyed.

It was a miracle that no one was killed by the Oakfield tornado. Homes were lifted from their foundations and deposited in adjacent yards or across the street. The community's middle school was destroyed as were two churches and a church school. One of the village's largest employers, the Friday Canning Company, had its warehouses literally shredded and its contents, cans of corn, strewn for miles around. The farming community was hit very hard. Many farmers lost their homes, farm buildings and crops. Hundreds of acres of corn waiting to be picked and packed at the canning plant were destroyed. Thousands of trees were down and created a serious debris removal problem. Power poles were snapped and most of the community lost power, some for as long as two weeks.

More recently, an F3 tornado struck a rural section of central Door County in northeast Wisconsin during the evening of August 23, 1998. The multiple-vortex tornado was on the ground for nearly 14 minutes and carved a path of damage 5.1 miles long and 1/4 to over 1/2 mile wide at times. Damage was estimated at nearly $7 million. Fortunately, only 2 people were injured and no one was killed.

There were several tornadoes that struck Wisconsin in 2000. A very early tornado touched down near General Mitchell Airport in Milwaukee on March 8. The National Weather Service classified the tornado as a Category F1. Tornadoes of this category are considered moderate, with 73-112 mph winds. In just a few minutes the tornado caused $381,000 worth of damage to about 75 homes and $3.8 million in damage to commercial real estate. On May 12, 2000, a major storm or supercell developed in west central Wisconsin. Chilton and St. Nazianz in Manitowoc County were particularly hard-hit by hail and wet microbursts that produced straight line winds over 100 mph and a brief F0 to F1 tornado. In addition, three tornadoes were documented on June 1, in Dodge, Juneau and Monroe Counties. The one in Dodge County, an F2, occurred just after 6:00 p.m. and was on the ground for more than 16 miles. The tornado destroyed or did major damage to several dozen homes in Iron Ridge, a small community of 800.

On June 18, 2001, a fierce F3 tornado hit Burnett and Washburn Counties. This tornado touched down near Grantsburg and continued traveling east for over 25 miles to an area just outside Spooner. Some witnesses said the tornado split into 3 funnel clouds in some areas. There was extensive damage and destruction along the tornado's path. Damage was most concentrated in a six-block wide area of the Village of Siren, where numerous homes and businesses were completely leveled and tragically, 3 people were killed and 16 people injured.

Programs: Each April, Wisconsin Emergency Management, in conjunction with the National Weather Service, the Department of Public Instruction and local emergency government agencies conducts the annual Tornado Awareness Week and tornado drill. This campaign focuses on schools, educating students on tornado safety and increasing their awareness of this significant weather hazard. A statewide tornado drill is conducted with the National Weather Service commencing this exercise by broadcasting simulated weather bulletins. Many schools actually go to shelters as part of the exercise.

As part of these awareness efforts, state and local emergency managers are emphasizing the importance of hazard mitigation in reducing the impacts of these devastating storms. Local officials are urged to adopt and enforce building codes that make structures more resistant to wind damage. Special efforts are made to reach out to those who live in mobile homes or manufactured housing. Such structures are particularly vulnerable to damage in storms that have wind speeds in excess of 80 mph, even when the structures are properly anchored. Residents of such structures are advised to leave them immediately and seek protection in a suitable shelter. Mobile home park owners are also urged to provide residents with tornado shelters or make arrangements with a nearby facility for use as a shelter.

In the event of a tornado threat, the National Weather Service posts weather bulletins. These consist of issuing tornado watches and tornado warnings for areas of the state. These bulletins are disseminated over a number of telecommunication channels including: NOAA Weather Radio, the NOAA Weather Wire and the state law enforcement TIME system. These communications systems are routinely monitored by local media, which rebroadcast the weather bulletins over public and private television and radio stations.

Tornado Damage Scale

Scale	Wind Speeds	Damage	Frequency
F0	40 to 72 MPH	Some damage to chimneys, TV antennas, roof shingles, trees and windows.	29%
F1	73 to 112 MPH	Automobiles overturned, carports destroyed, trees uprooted	40%
F2	113 to 157 MPH	Roofs blown off homes, sheds and outbuildings demolished, mobile homes overturned.	24%
F3	158 to 206 MPH	Exterior walls and roofs blown off homes. Metal buildings collapsed or are severely damaged. Forests and farmland flattened.	6%
F4	207 to 260 MPH	Few walls, if any, standing in well-built homes. Large steel and concrete missiles thrown far distances.	2%
F5	261 to 318 MPH	Homes leveled with all debris removed. Schools, motels and other larger structures have considerable damage with exterior walls and roofs gone. Top stories demolished.	less than 1%

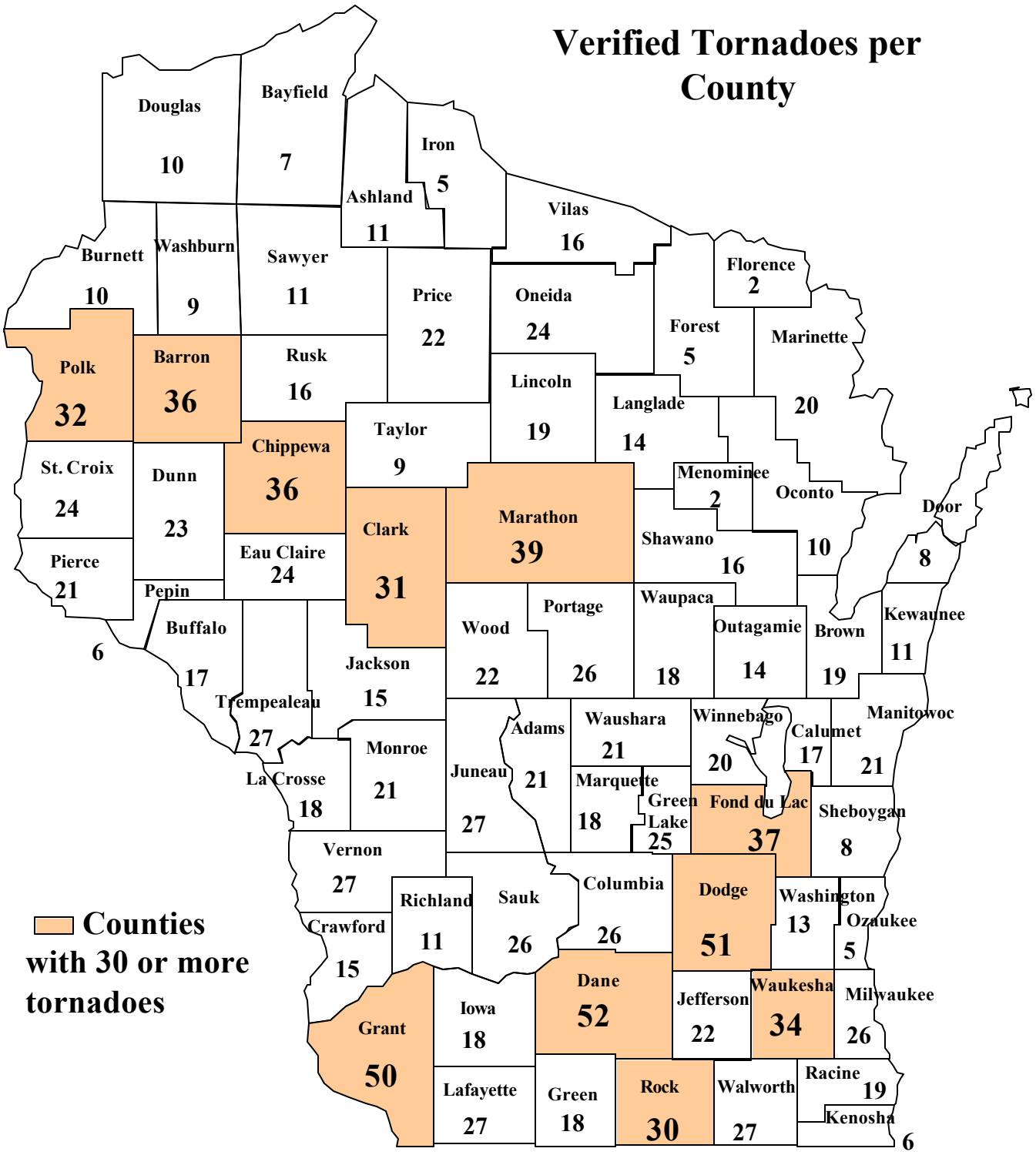
Source: National Weather Service: http://www.nws.noaa.gov/er/cae/svrwx/tornado/tornado.htm

United States Tornado Deaths by Location/Circumstance 1985-1998

Year	Mobile Home	Permanent Home	Vehicle	Business	School or Church	Outdoors	Unknown	Total
1999	39	35	6	8	0	6	1	94
1998	65	40	15	7	0	3	0	130
1997	30	23	3	3	0	7	1	67
1996	14	8	2	0	0	0	1	25
1995	8	15	4	0	0	3	0	30
1994	26	14	3	0	20	6	0	69
1993	13	6	7	3	1	3	0	33
1992	20	18	0	0	0	1	0	39
1991	20	3	4	0	0	12	0	39
1990	7	11	14	15	5	1	0	53
1989	12	8	16	4	9	0	1	50
1988	21	6	3	2	0	0	0	32
1987	24	7	3	0	22	3	0	59
1986	7	3	3	0	0	0	2	15
1985	28	40	4	0	0	0	22	94
Total	**334**	**237**	**87**	**42**	**57**	**45**	**28**	**829**
Percent	**40.3%**	**28.6%**	**10.5%**	**5.1%**	**6.9%**	**5.4%**	**3.4%**	**100%**

Source: National Weather Service: http://www.spc.noaa.gov/climo/torn/locations.html.

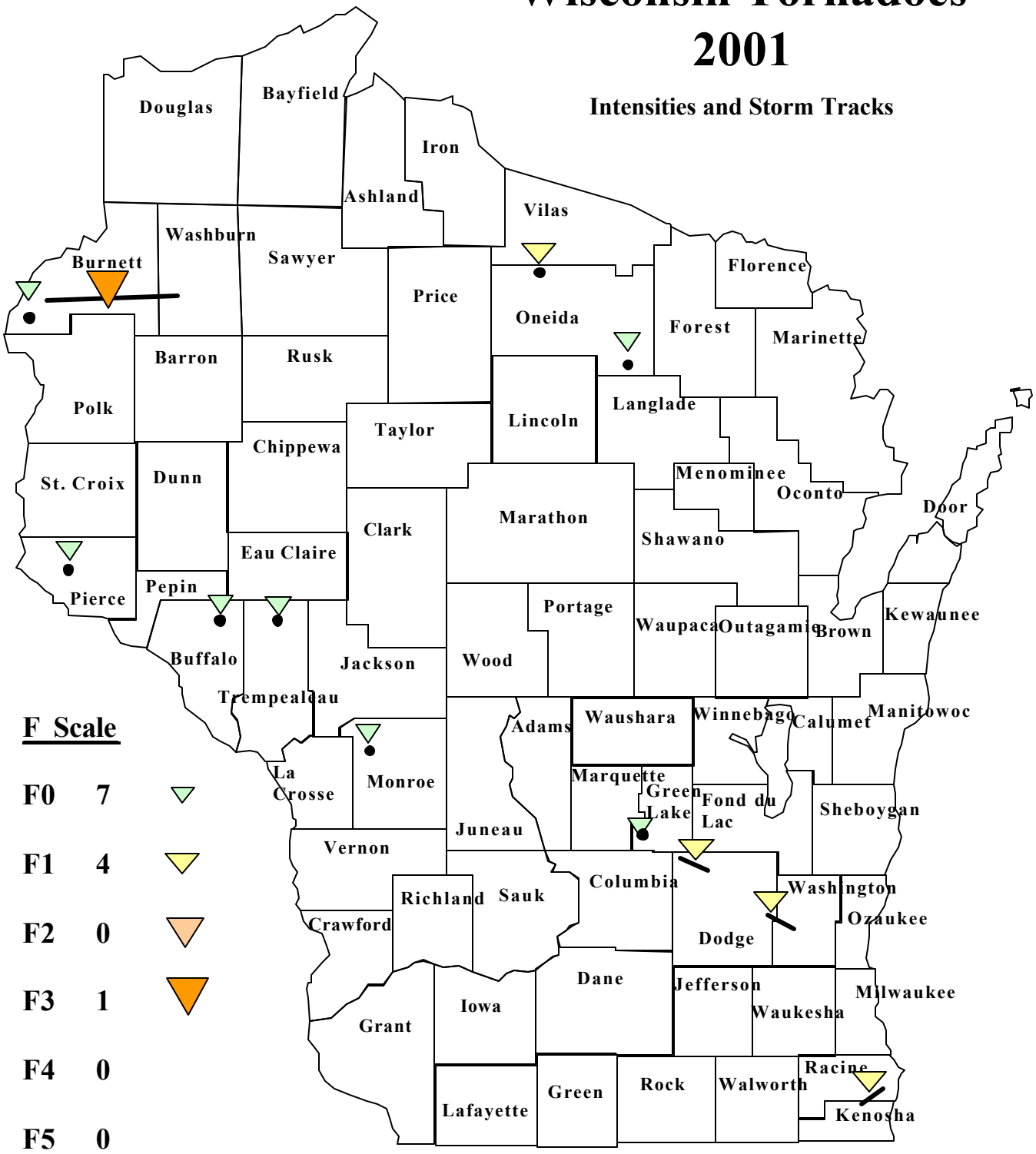
Wisconsin Tornadoes 1844 - 2001



Source: Rusty Kapela, National Weather Service, Milwaukee

Wisconsin Tornadoes 2001

Intensities and Storm Tracks



F Scale

F0	7
F1	4
F2	0
F3	1
F4	0
F5	0

Tornado Path —

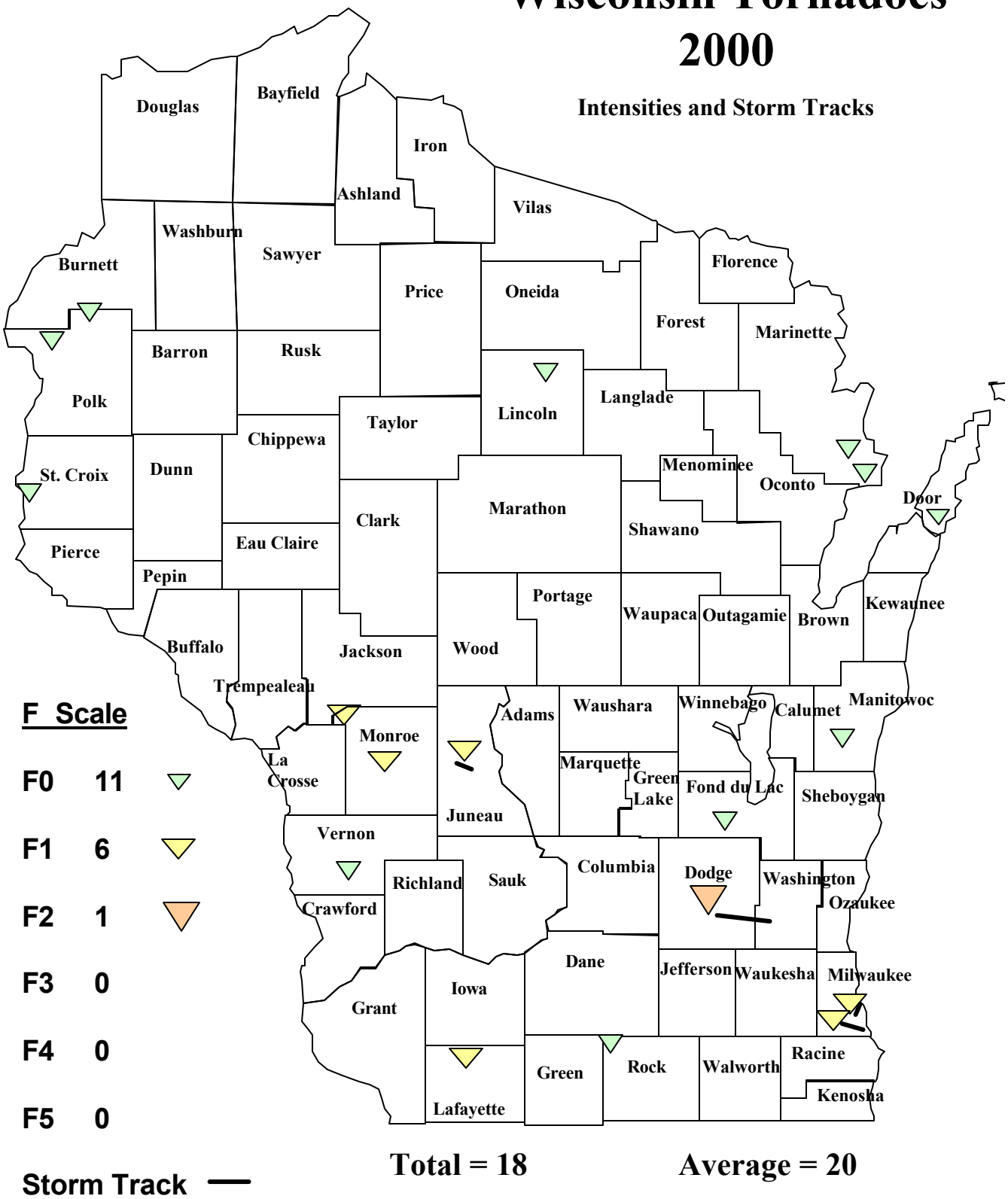
Brief Tornado •

Total = 12 **Average = 20**

Source: Rusty Kapela, National Weather Service

Wisconsin Tornadoes 2000

Intensities and Storm Tracks



Source: Rusty Kapela, National Weather Service

WINTER STORMS

Hazard Description: Winter storms can vary in size and strength and include heavy snowstorms, blizzards, freezing rain, sleet, ice storms and blowing and drifting snow conditions. Extremely cold temperatures accompanied by strong winds can result in wind chills that cause bodily injury such as frostbite and death.

Hazard Assessment: A variety of weather phenomena and conditions can occur during winter storms. For clarification, the following are National Weather Service approved descriptions of winter storm elements:

Heavy snowfall - the accumulation of six or more inches of snow in a 12-hour period or eight or more inches in a 24-hour period.

Blizzard - the occurrence of sustained wind speeds in excess of 35 miles per hour accompanied by heavy snowfall or large amounts of blowing or drifting snow.

Ice storm - an occurrence where rain falls from warmer upper layers of the atmosphere to the colder ground, freezing upon contact with the ground and exposed objects near the ground.

Freezing drizzle/freezing rain - the effect of drizzle or rain freezing upon impact on objects that have a temperature of 32 degrees Fahrenheit or below.

Sleet - solid grains or pellets of ice formed by the freezing of raindrops or the refreezing of largely melted snowflakes. This ice does not cling to surfaces.

Wind chill - an apparent temperature that describes the combined effect of wind and low air temperatures on exposed skin.

Much of the snowfall in Wisconsin occurs in small amounts of between one and three inches per occurrence. Heavy snowfalls that produce at least eight to ten inches accumulation happen on the average only five times per season. The northwestern portion of Wisconsin receives most of its snow during early and late season storms, while southwestern and southeastern counties receive heavy snows more often in mid-winter. Snowfall in Wisconsin varies between the seasonal average of approximately 30 inches in the south central area of the state to over 100 inches a year in the extreme northwestern counties.

True blizzards are rare in Wisconsin. They are more likely to occur in northwestern Wisconsin than in southern portions of the state, even though heavy snowfalls are more frequent in the southeast. However, blizzard-like conditions often exist during heavy snowstorms when gusty winds cause the severe blowing and drifting of snow.

Both ice and sleet storms can occur at anytime throughout the winter season from October into April. Early and late season ice and sleet storms are generally restricted to northern Wisconsin, such as the November 7-8, 1943, and April 16-17, 1939, storms. Otherwise, the majority of these storms occur in southern Wisconsin. In a typical winter season there are 3-5 freezing rain events

and a major ice storm occurs on a frequency of about once every other year. If a half-inch of rain freezes on trees and utility wires, extensive damage can occur, especially if accompanied by high winds that compound the effects of the added weight of the ice. There are also between three and five instances of glazing (less than 1/4 inch of ice) throughout the state during a normal winter.

Winter storms present a serious threat to the health and safety of affected citizens and can result in significant damage to property. Heavy snow or accumulated ice can cause the structural collapse of buildings, down power lines or isolate people from assistance or services.

Historical Frequency and Significant Incidents: Generally, the winter storm season in Wisconsin runs from October through March. Severe winter weather has occurred, however, as early as September and as late as the latter half of April and into May in some locations in the state.

The first significant winter event of 2001 was an ice storm that left a ¼ inch of ice over large portions of Oneida and Forest Counties. In addition, several heavy snowfalls were recorded in northern Wisconsin in 2001. The first heavy snow of the year occurred February 24-25, covering Douglas County with 20 inches of snow. A November 26-28 storm left 12 to 20 inches in a band from Burnett to Vilas County. A series of lake-effect snowfalls from Lake Superior left accumulations of 1 to 4 feet from Douglas to Vilas County. However, southern Wisconsin and much of the state received far less than average snowfall during 2001 and winter temperatures were generally quite mild.

December 2000, in contrast, was one of the 10 coldest Decembers on record for most of the state. In addition to the low temperatures, record or near record snow depths of 15-34" occurred in much of southern Wisconsin during December. As a result of record snowfalls, thirteen counties received a Presidential Emergency Declaration and were eligible to receive federal funds for extraordinary expenses associated with clearing roads and emergency response efforts. The counties declared in the snow emergency were Columbia, Dane, Door, Green, Kenosha, Kewaunee, Manitowoc, Milwaukee, Racine, Rock, Sheboygan, Walworth and Waukesha Counties.

The winter of 1998-1999 was quite mild. However, a heavy snowfall occurred January 1-3, 1999. More than 10 inches fell in most southern counties with parts of Kenosha, Milwaukee, Ozaukee, Walworth, Washington and Waukesha Counties receiving more than 18 inches. The record for seasonal snowfall belongs to Hurley, WI. In the winter of 1996-97 over an 8-month period a total of 277.7 inches fell in Hurley. As that winter progressed, it became difficult to clear the streets of Hurley because there was no place to put the snow.

Other notably heavy snowfalls occurred in 1994 and 1991. In February 1994, 15 or more inches of snow were deposited in areas of Vernon, Juneau, Dane, Dodge and Columbia counties. In late November 1991, a snowstorm struck northwestern Wisconsin and left accumulations of 18-20 inches in Sawyer County and over ten inches of snow in Bayfield, Douglas, Burnett, Polk, St. Croix, Barron, Washburn, Ashland and Iron Counties. A heavy snowstorm the previous week dumped ten or more inches of snow in a diagonal band from Vernon, La Crosse and Buffalo Counties in the south to the northern counties of Iron, Vilas and Forest. Another storm during the period October 31-November 2, 1991, left large amounts of snow in northwest Wisconsin, with 35

inches in areas of Douglas County and over 30 inches of snow in Bayfield, Polk, St. Croix and Pierce Counties.

A statewide blizzard occurred December 2-4, 1990, depositing ten or more inches of snow across the central and southern portions of the state. Snowfalls of 22 inches were recorded in Juneau and Adams Counties, 20 inches in Marquette County, 19 inches in Dodge and Washington Counties and 17-18 inches in Columbia and Dane Counties. This excessive snowfall throughout such a large area of the state severely taxed capabilities to clear and remove snow.

Blizzard-like conditions occurred during the winter of 1981-82 when extremely cold temperatures were accompanied by wind speeds gusting to 50 mph. Wind chill factors reached 100 degrees below zero and severely affected the health and safety of those who ventured outdoors. Near blizzard conditions also existed in January 1979 when record snowfalls were recorded in many areas of the state and winds gusted to over 30 mph. Many persons were isolated from assistance and services as roads drifted shut and highway crews were unable to keep them open. Conditions were extremely hazardous in the City of Milwaukee and Racine County where a Presidential Emergency Declaration was obtained to assist in snow removal operations.

In March 1976 an ice storm of disastrous proportions occurred in the southern portion of the state. This storm was of such magnitude and caused so significant an amount of damage that a Presidential Disaster Declaration was obtained. This storm affected 22 counties, resulted in extensive power outages and caused over $50 million in damage.

Programs: Wisconsin Emergency Management, in conjunction with the National Weather Service, other state agencies and local emergency management organizations, provides awareness and preparedness information to the citizens of Wisconsin. This information is provided in three severe weather awareness campaigns conducted annually, each focusing on the prevalent weather hazard at that time. In November each year, Winter Awareness Week focuses on informing and educating people concerning the hazards presented by severe winter weather and information on preparedness for extreme weather conditions during winter.

In the event of severe winter weather, the National Weather Service posts winter weather bulletins. These bulletins consist of advisories, watches and warnings that are issued concerning expected winter weather conditions. Some are used to alert the public of situations such as *snow, winter weather, freezing rain or freezing drizzle* and *blowing snow advisories*. Others are used to warn the public of more serious weather situations which could pose a threat to life and property: *winter storm watch* and *winter storm, heavy snow, blizzard, ice storm* and *sleet warnings*. There are also bulletins that are not associated with precipitation, but are used to alert and warn like *freeze, wind* and *wind chill advisories* and *wind chill warnings*. These bulletins are disseminated over a number of telecommunication channels including the NOAA Weather Radio, the NOAA Weather Wire and the state law enforcement TIME system. These weather information sources are routinely monitored by local media, which rebroadcast the weather bulletins over public and private television and radio stations.

REFERENCES

Center for Earthquake Information and Research, University of Memphis, Tennessee. Accessed on the Internet at: http://www.cordova.ceri.memphis.edu.

Curran, E. B., R. L. Holle and R. E. Lopez. *Lightning Fatalities, Injuries and Damage Reports in the United States, 1959-1994.* National Weather Service, Scientific Services Division, Ft Worth, TX. This report is officially known as NOAA Tech Memorandum NWS SR-193.

Detroit Free Press Newspaper, March 18, 2000. *Less Snow this Winter Means Less Great Lakes Water this Summer.* Detroit Free Press, Detroit, Michigan. Accessed on the Internet at: http://www.lre.usace.army.mil/functions/pa/news/3-18-2000.pdf.

Esposito, Katherine. 1999. *Dammed if You Do and Damned if You Don't,* Wisconsin Natural Resources Magazine, April 1999. Wisconsin Department of Natural Resources. Accessed on the Internet at http://www.wnrmag.com/stories/1999/apr99/dams.htm.

Federal Bureau of Investigation, 1998. *Terrorism in the United States, 1997*. Federal Bureau of Investigation, Washington, D.C.

Federal Department of Transportation, Office of Pipeline Safety. *Natural Gas Distribution Incident Data.* Accessed on the Internet June 2002 at http://ops.dot.gov/IA98.htm.

Federal Emergency Management Agency (FEMA) 1999. *Progress through Partnerships: The National Dam Safety Program in Fiscal Years 1998-1999.* December, 1999.

Hart, David. 1997. *A Resource Guide for Great Lakes Coastal Hazards in Wisconsin*. Wisconsin Coastal GIS Applications Project, University of Wisconsin-Madison. Accessed on the Internet at: http://www.lic.wisc.edu/coastgis/urpl999.htm.

Center for Disease Control *Lightning-Associated Deaths - United States, 1980-1995*. Morbidity and Mortality Weekly Report (MMWR) May 22, 1998 / 47(19); 391-394. Accessed via Internet March 2000 at http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00052833.htm.

Mid-America Earthquake Center, University of Illinois at Urbana-Champaign. *Mid-America Earthquake Hazard*. Accessed on the Internet at: http://mae.ce.uiuc.edu/Research/SeismicHazard/index.html.

National Transportation Safety Board. 2002. Aviation Accident Database: Query made in June 2002. Accessed on the Internet at: http://www.ntsb.gov/NTSB/Query.htm.

National Weather Service, Sullivan Office (Madison-Milwaukee), 2000-2002. Rusty Kapela. Information obtained through personal communication, Internet publications and informal reports. Internet address is http://www.crh.noaa.gov/mkx/climate.htm.

Springman, Roger and Stephen M. Born, 1979. *Wisconsin's Shore Erosion Plan: An Appraisal of Options and Strategies*. Prepared for the Wisconsin Coastal Management Program. June 1979.
US Army Corps of Engineers, 1999. *Great Lakes Update*, Vol. 135. April, 5, 1999. US Army Corps of Engineers, Detroit District.

US Army Corps of Engineers, 2000. *Great Lakes Update*, Vol. 139. April 6, 2000. US Army Corps of Engineers, Detroit District.

US Geological Survey, National Earthquake Information Center. *Magnitude/Intensity Comparison*. http://gldss7.cr.usgs.gov/neis/general/handouts/mag_vs_int.html.

Vatis, Michael A., Director, 2001. *Cyber Attacks During the War on Terrorism: A Predictive Analysis.* Institute for Security Technology Studies at Dartmouth College, Hanover, NH. Available on-line at http://www.ists.dartmouth.edu/ISTS/counterterrorism/cyber_attacks.htm.

Von Hake, Carl A. *Earthquake Information Bulletin*, Volume 10, Number 3, May - June 1978.

Wisconsin Coastal Management Program. 1992. *State of Wisconsin Coastal Management Program Needs Assessment and Multi-Year Strategy*. Wisconsin Department of Administration, Madison WI.

Wisconsin Coastal Management Program. 2002. *Wisconsin Great Lakes Chronicle-2002*. Wisconsin Department of Administration, Madison WI.

Wisconsin Department of Military Affairs, Division of Emergency Management. *State of Wisconsin Radiological Incident Response Plan, Volume 1.* Madison WI.

Wisconsin Department of Natural Resources, 1993. *The Floods of 1993: The Wisconsin Experience*. Departmental Report, December 1993. Figure 9.